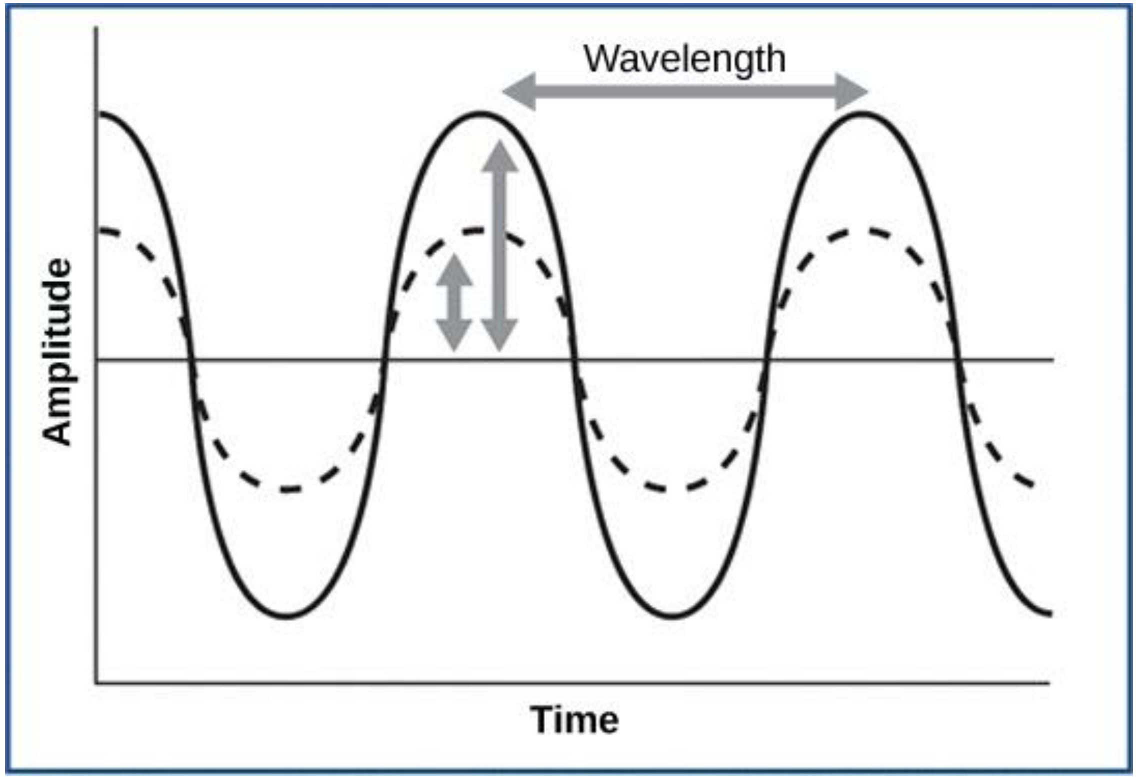
Noise pollution

What is Noise?

- Unwanted sound judged to be unpleasant, loud or disruptive to hearing.
- Sound is measured based on the amplitude and frequency of a sound wave.

- Amplitude measures how forceful the wave is.
- The energy in a sound wave is measured in decibels (dB), the measure of loudness, or intensity of a sound; this measurement describes the amplitude of a sound wave.
- Decibels (dB) are expressed in a logarithmic scale. On the other hand, pitch describes the frequency of a sound and is measured in hertz (Hz)



Types of noise

- **Continuous Noise**
- It is noise that is produced continuously by machinery that keeps running without interruption. This could come from factory equipment, heating or ventilation systems.
- **Intermittent Noise**
- Intermittent noise is a noise level that increases and decreases rapidly. This might be a freight train passing by, factory equipment that operates in cycles or aircraft overhead.
- **Impulsive Noise**
- Impulsive noise is most commonly associated with the construction and demolition industry. This sudden burst of noise can startle you by its fast and surprising nature. Impulsive noises are commonly created by explosions or construction equipment such as pile drivers.
- **Low Frequency Noise**
- Low frequency noise makes up part of the fabric of our daily soundscape. Whether it's the low background humming from power plants or the roaring of large diesel engines, we are exposed to low frequency noise constantly. This is also the hardest type of noise to reduce at source, so it can easily spread for miles around.

Sources of noise pollution

- Traffic (road, air, rail)
- Domestic
- Industrial
- Incompatible landuse
- Construction

Noise measurement

S/N	Equipment	Specification/Area of usage
1	Sound level meter	Type-0: Laboratory reference standard
		Type-1: Lab use and field use in specified controlled environment
		Type-2: General field use (Commonly used)
		Type-3: Noise survey
2	Impulse meters	For measurement of impulse noise levels e.g. hammer blows, punch press strokes etc.
3	Frequency analyzers	For detailed design and engineering purpose using a set of filters
4	Graphic recorders	Attached to sound level meter. Plots the SPL as a function of time on a moving paper chart
5	Noise dosimeters	Used to find out the noise levels in a working environment. Attached to the worker
6	Calibrators	For checking the accuracy of sound level meters

Noise measurement

- The main instrument to measure sounds in the air is the Sound Level Meter.
- There are many different varieties of instruments that are used to measure noise - **Noise Dosimeters** are often used in occupational environments

A **noise dosimeter** is a specialized sound level meter intended specifically to measure the noise exposure of a person integrated over a period of time; usually to comply with Health and Safety regulations such as the Occupational Safety and Health (OSHA) 29 CFR 1910.95

The Occupational Safety and Health Administration's (OSHA's) Noise standard (29 CFR 1910.95)

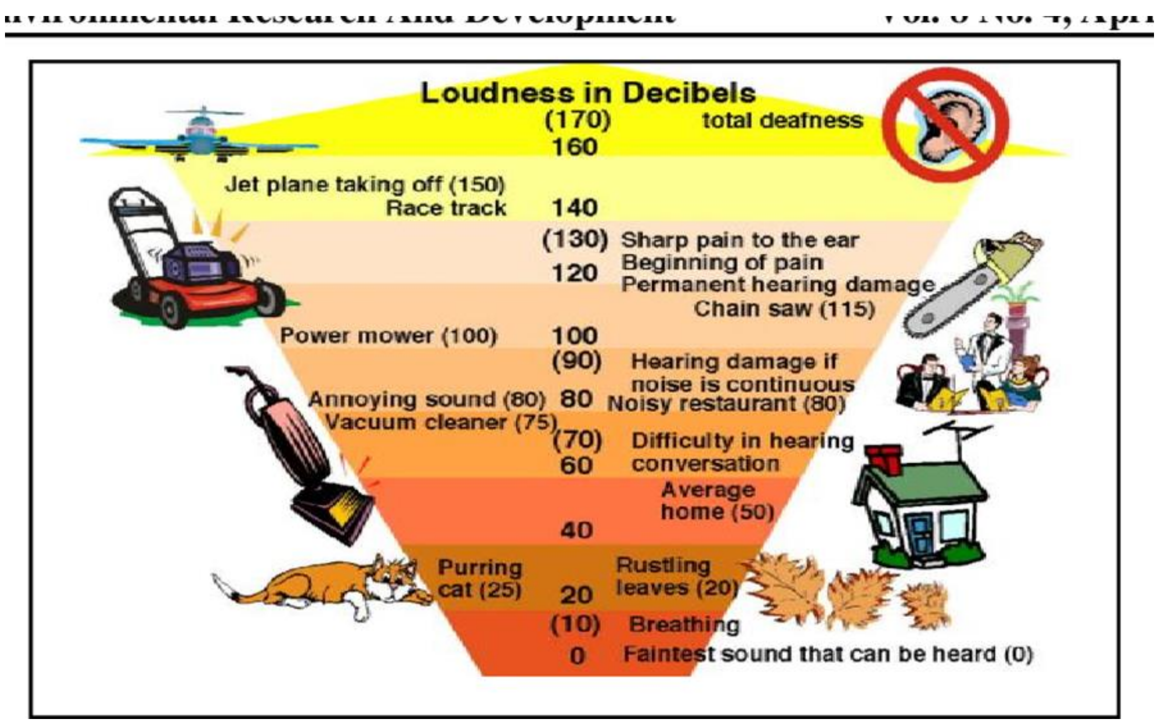
- requires employers to have a hearing conservation program in place if workers are exposed to a time-weighted average (TWA) noise level of 85 decibels (dBA) or higher over an 8-hour work shift. OSHA's permissible exposure limit (PEL) for noise exposure is 90 dBA for an 8-hour TWA and the standard uses a 5 dBA exchange rate.
    - This means that when the noise level is increased by 5 dBA, the amount of time a person can be exposed is cut in half. For example, a person who is exposed to noise levels of 95 dBA (5 dBA above the OSHA PEL of 90 dBA) can be exposed for only 4 hours in order to be within the daily OSHA PEL).

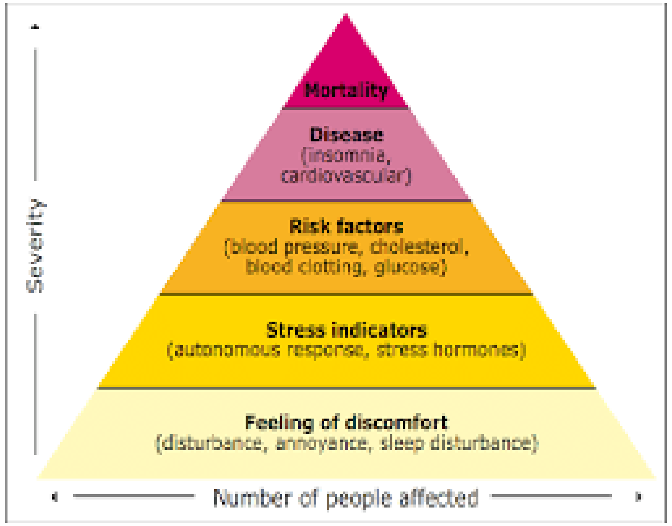
Noise Level	Exposure Limit
90 dBA	8.0 hours
92 dBA	6.0 hours
95 dBA	4.0 hours
97 dBA	3.0 hours
100 dbA	2.0 hours
102 dBA	1.5 hours
105 dBA	1.0 hours
110 dBA	30 minutes
115 dBA	15 minutes

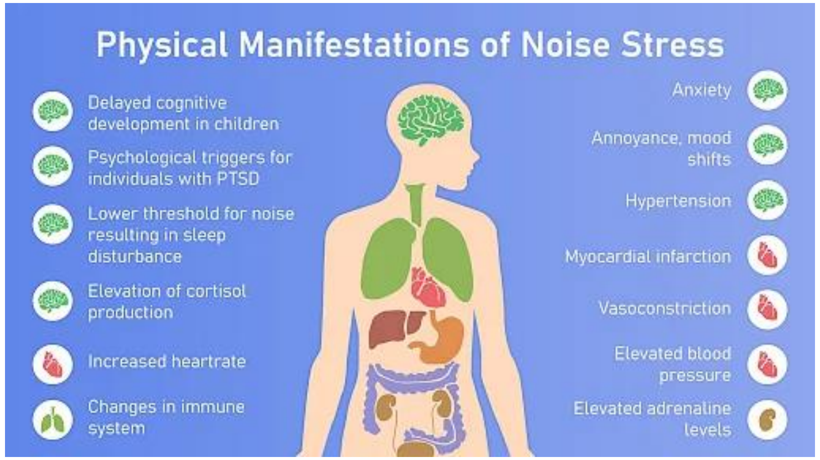
Table 1. OSHA's Permissible Noise Exposure Limits.

Effects of Noise

- Exposure to high levels of noise can lead to:
- Hearing loss;
- Tinnitus (ringing in the ear);
- Stress; • Anxiety;
- High blood pressure;
- Gastrointestinal problems; and
- Chronic fatigue.

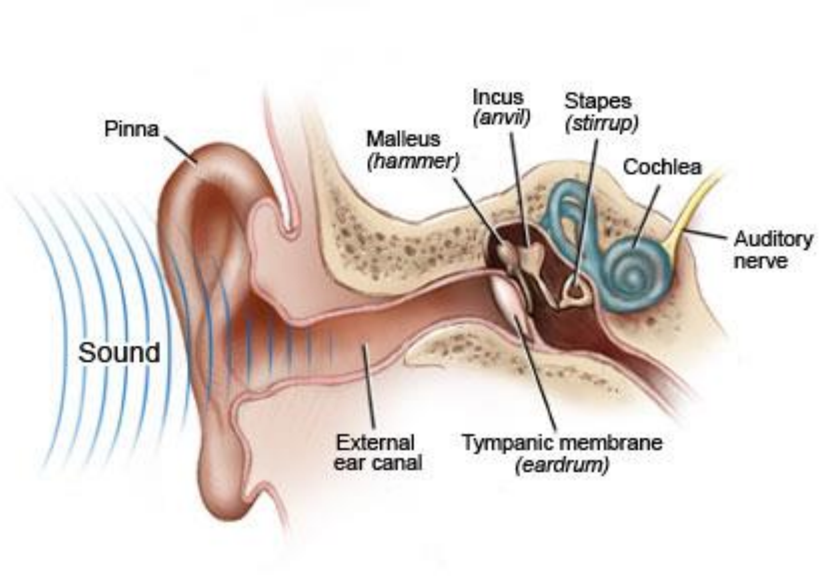

Loudness in Decibels
(170) total deafness
160
Jet plane taking off (150)
Race track 140
(130) Sharp pain to the ear
120 Beginning of pain
Permanent hearing damage
Chain saw (115)
Power mower (100) 100
(90) Hearing damage if noise is continuous
Annoying sound (80) 80 Noisy restaurant (80)
Vacuum cleaner (75)
(70) Difficulty in hearing
60 conversation
Average home (50)
40
Purring cat (25)
20 Rustling leaves (20)
(10) Breathing
0 Faintest sound that can be heard (0)


Mortality
Disease
(insomnia, cardiovascular)
Risk factors
(blood pressure, cholesterol, blood clotting, glucose)
Stress indicators
(autonomous response, stress hormones)
Feeling of discomfort
(disturbance, annoyance, sleep disturbance)
Severity
Number of people affected


Physical Manifestations of Noise Stress
Delayed cognitive development in children
Psychological triggers for individuals with PTSD
Lower threshold for noise resulting in sleep disturbance
Elevation of cortisol production
Increased heartrate
Changes in immune system
Anxiety
Annoyance, mood shifts
Hypertension
Myocardial infarction
Vasoconstriction
Elevated blood pressure
Elevated adrenaline levels

- Noise Induced Hearing Loss (NIHL). The NIHL is irreversible subtle change in the sensory cells and other structures in the organ of Corti (Sensory Hair Cells) in the Cochlea. As a result of which, the hair cells and supporting cells disintegrate and ultimately the nerve fibers' that weaken the hair cells disappear resulting in permanent threshold shift and hence irreversible hearing loss at the higher frequencies.

- The adverse effects of Noise on hearing may be classified into three categories namely, temporary threshold shift (TTS), Permanent threshold shift (PTS) and acoustic Trauma.



Control

- SOURCE CONTROL BY DESIGN INVOLVES
- reduction of mechanical shock between parts
- Reduction of noise resulting from out-of-balance
- Reduction of noise resulting from friction between metal parts
- Reduction of noise resulting from the vibration of large structures (plates, beams, etc.)

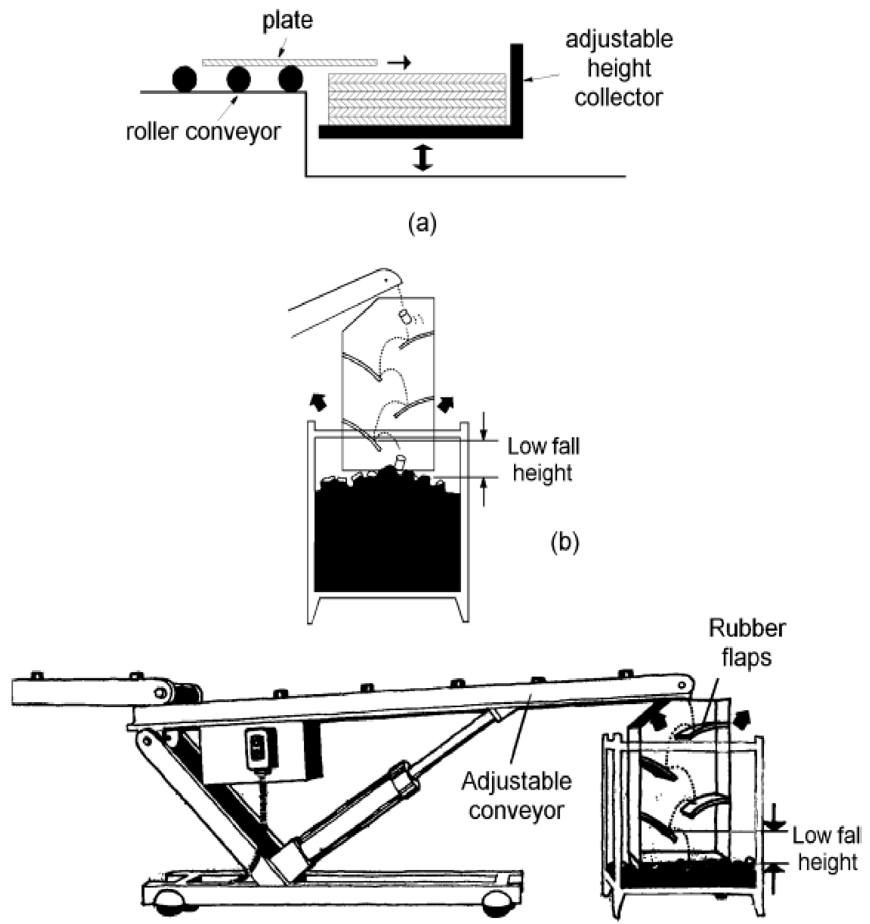


Figure 10.5. Examples of decrease of dropping height (ASF, 1977, with additions)
(a) Adjustable height collector.
(b) Adjustable height conveyor with rubber flaps.

- reduction of noise resulting from fluid flow

Figure 10.10. Vibration isolation by separation (ASF, 1977).

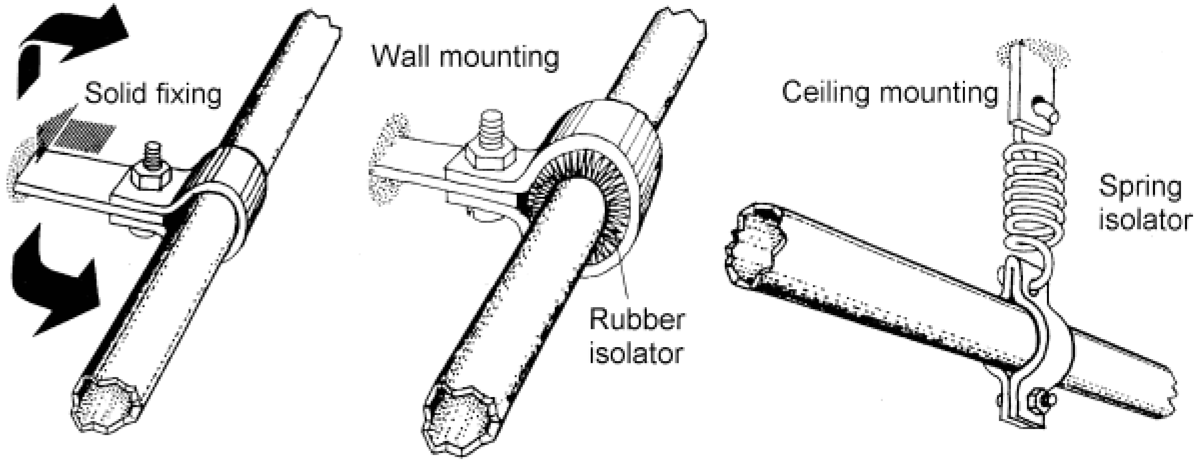
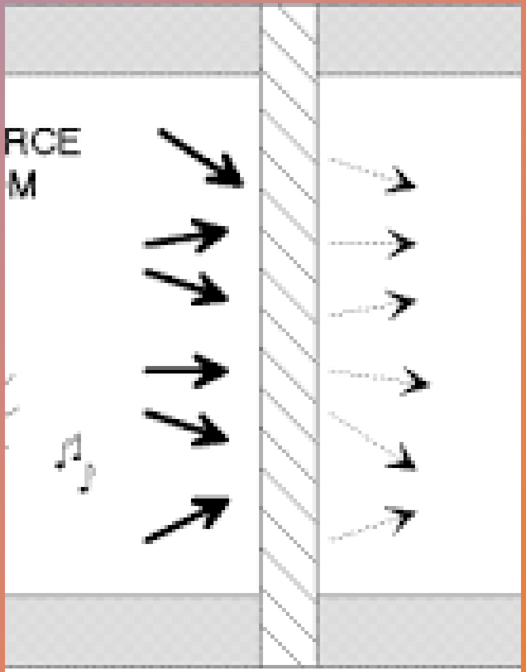
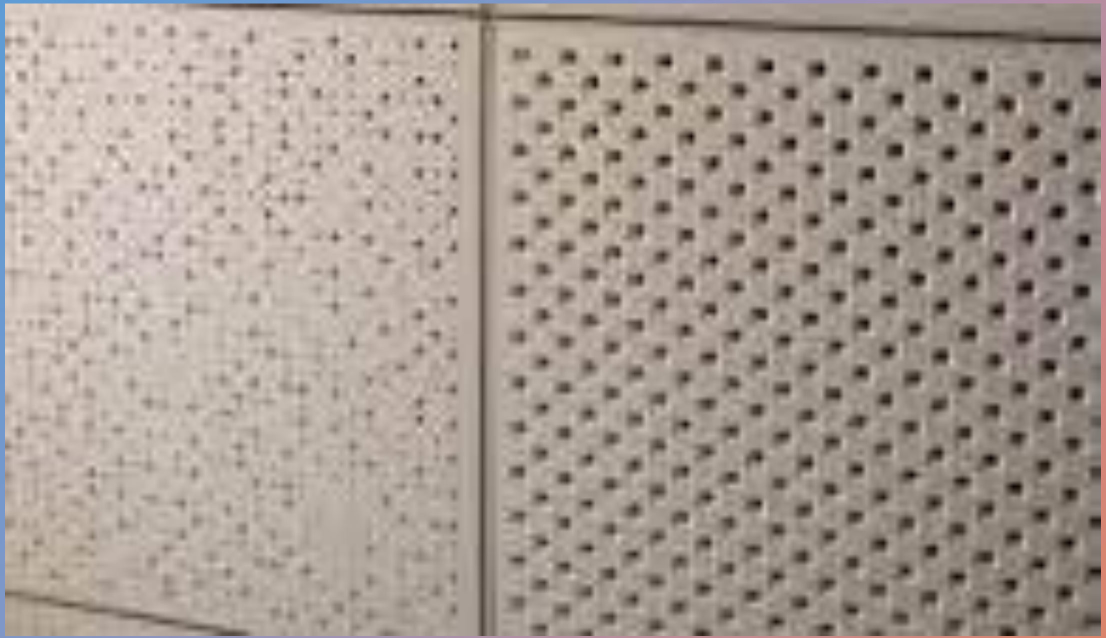


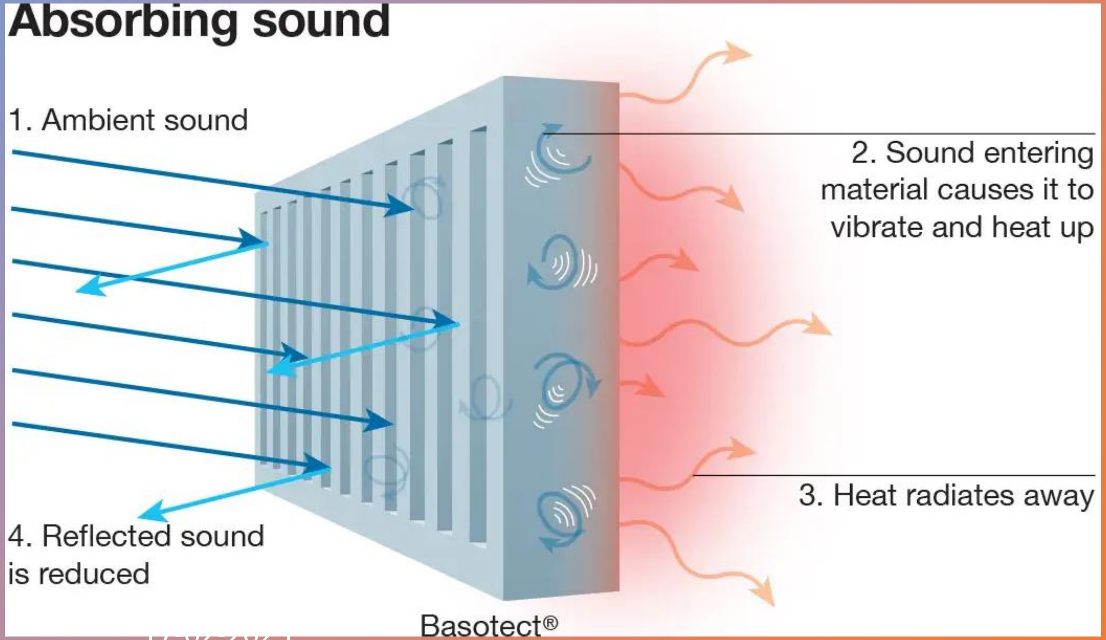
Figure 10.11. Reduction of vibration transmission from piping systems (ASF, 1977).



- CONTROL OF NOISE PROPAGATION
- Use of barriers (single walls), partial enclosures or full enclosure of the entire item of equipment.
- Use of local enclosures for noisy components on a machine.
- Use of reactive or dissipative mufflers; the former for low frequency noise or small exhausts, the latter for high frequencies or large diameter exhaust outlets.
- Use of lined ducts for air handling systems
- Reverberation control - the addition of sound absorbing material to reverberant spaces to reduce reflected noise fields.
- Use of silencers and lubricants





Sound absorption and reflection

- Sound absorbing materials are fibrous, lightweight and porous, possessing a cellular structure of intercommunicating spaces. It is within these interconnected open cells that acoustic energy is converted into thermal energy. Thus the sound-absorbing material is a dissipative structure which acts as a transducer to convert acoustic energy into thermal energy.
- The actual loss mechanisms in the energy transfer are viscous flow losses caused by wave propagation in the material and internal frictional losses caused by motion of the material's fibres.
- The absorption characteristics of a material are dependent upon its thickness, density, porosity, flow resistance, fibre orientation, and the like.
- Common porous absorption materials are made from vegetable, mineral or ceramic fibres (the latter for high temperature applications) and elastomeric foams, and come in various forms. The materials may be prefabricated units, such as glass blankets, fibreboards, or lay-in.

Control at the receptor end

- Use of earmuffs and ear plugs
- Construction of green belts
- Public awareness
- Banning of loud horns
- Minimum use of loudspeakers
- Airports, industrial zones and highways could be located outside the city limits or residential and sensitive areas.
- Proper road planning, construction of fly overs and efficient traffic management to reduce traffic congestion.

Noise pollution control rules, 2000

Ambient Air Quality Standards in respect of Noise

Area Code	Category of Area / Zone	Limits in dB(A) Leq*	
		Day Time	Night Time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence Zone	50	40

- Restrictions on the use of loud speakers / public address system
- and sound producing instruments.-
- (1) A loud speaker or a public address system shall not be used except after obtaining written permission from the authority.
- (2) A loud speaker or a public address system or any sound producing instrument or a musical instrument or a sound amplifier shall not be used at night time except in closed premises for communication within, like auditoria, conference rooms, community halls, banquet halls or during a public emergency.
- Restrictions on the use of horns, sound emitting construction equipments and bursting of fire crackers:-
- (1) No horn shall be used in silence zones or during night time in residential areas except during a public emergency. (2) Sound emitting fire crackers shall not be burst in silence zone or during night time. (3) Sound emitting construction equipments shall not be used or operated during night time in residential areas and silence zones.

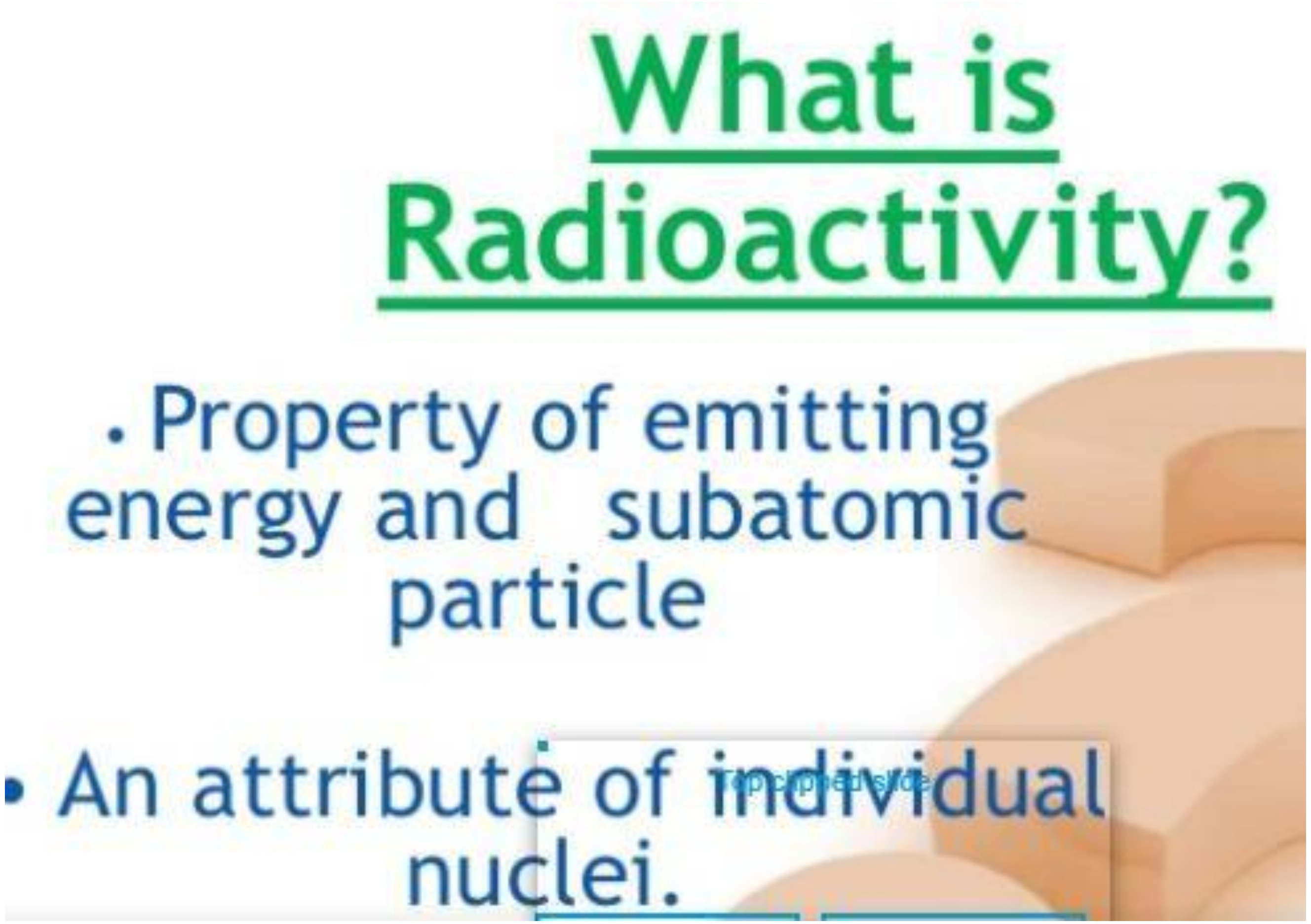
Continued…

Consequences of any violation in silence zone / area.-
Whoever, in any place covered under the silence zone / area commits any of the following offence, he shall be liable for penalty under the provisions
of the Act:-
(i) whoever, plays any music or uses any sound amplifiers,
(ii) whoever, beats a drum or tom-tom or blows a horn either musical or pressure, or trumpet or beats or sounds any instrument, or
(iii) whoever, exhibits any mimetic, musical or other performances of a nature to attract crowds.
(iv) whoever, bursts sound emitting fire crackers; or
(v) whoever, uses a loud speaker or a public address system.
Complaints to be made to the authority.- (1) A person may, if the noise level exceeds the ambient noise standards by 10 dB (A) or more given in the corresponding columns against any area / zone or, if there is a violation of any provision of these rules regarding restrictions imposed during night time, make a complaint to the authority. (2) The authority shall act on the complaint and take action against the violator in accordance with the provisions of these rules and any other law in force.

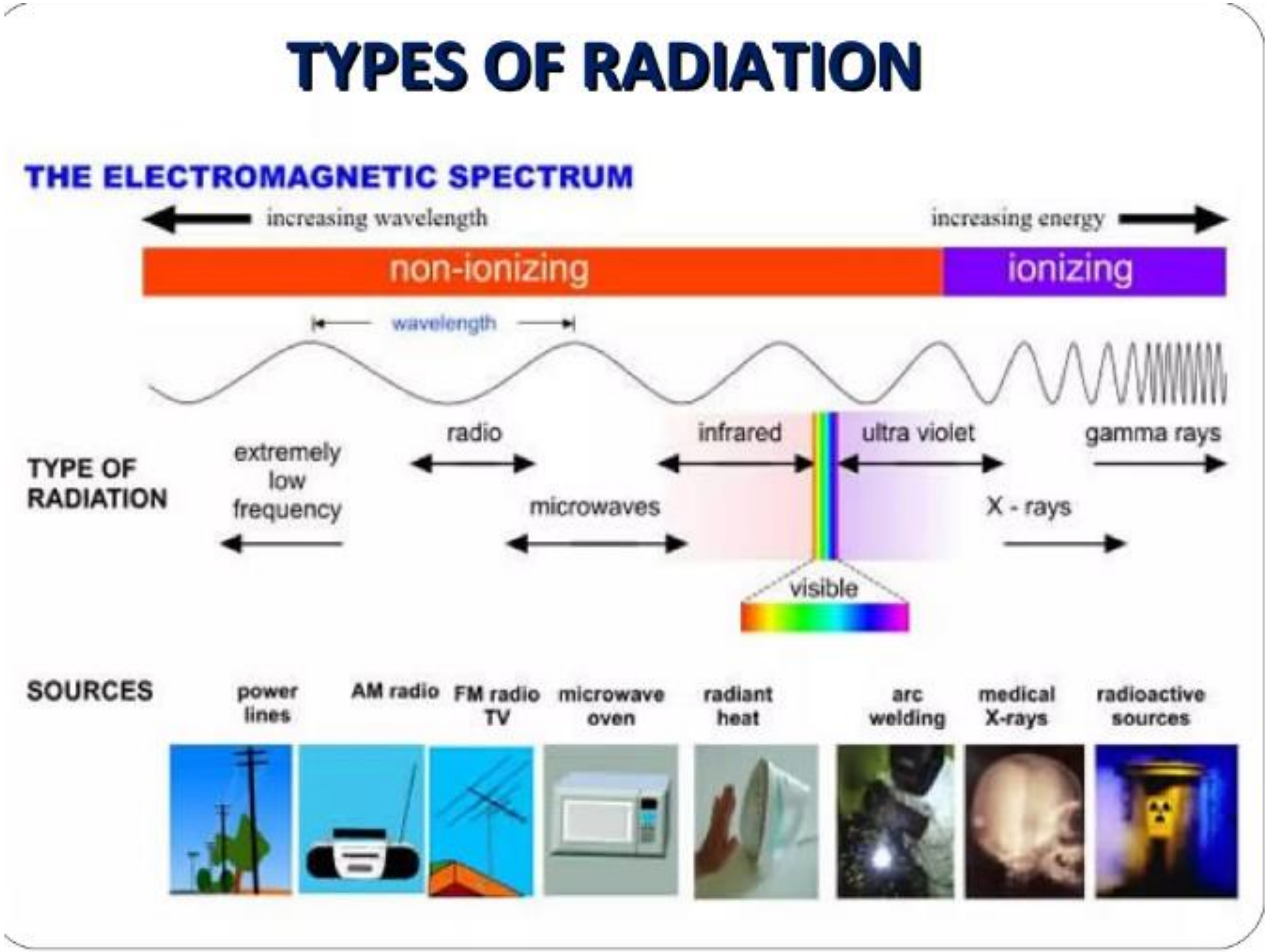
Radioactive waste

Radioactivity

Radioactivity is the phenomenon of the spontaneous disintegration of unstable atomic nuclei to atomic nuclei to form more energetically stable atomic nuclei.



Radiation types



Ratiocinative pollution

WHAT IS RADIATION POLLUTION?

Radiation pollution is caused by **radioactive** substances which emit **invisible** radiation released in the environment through **human activities**.

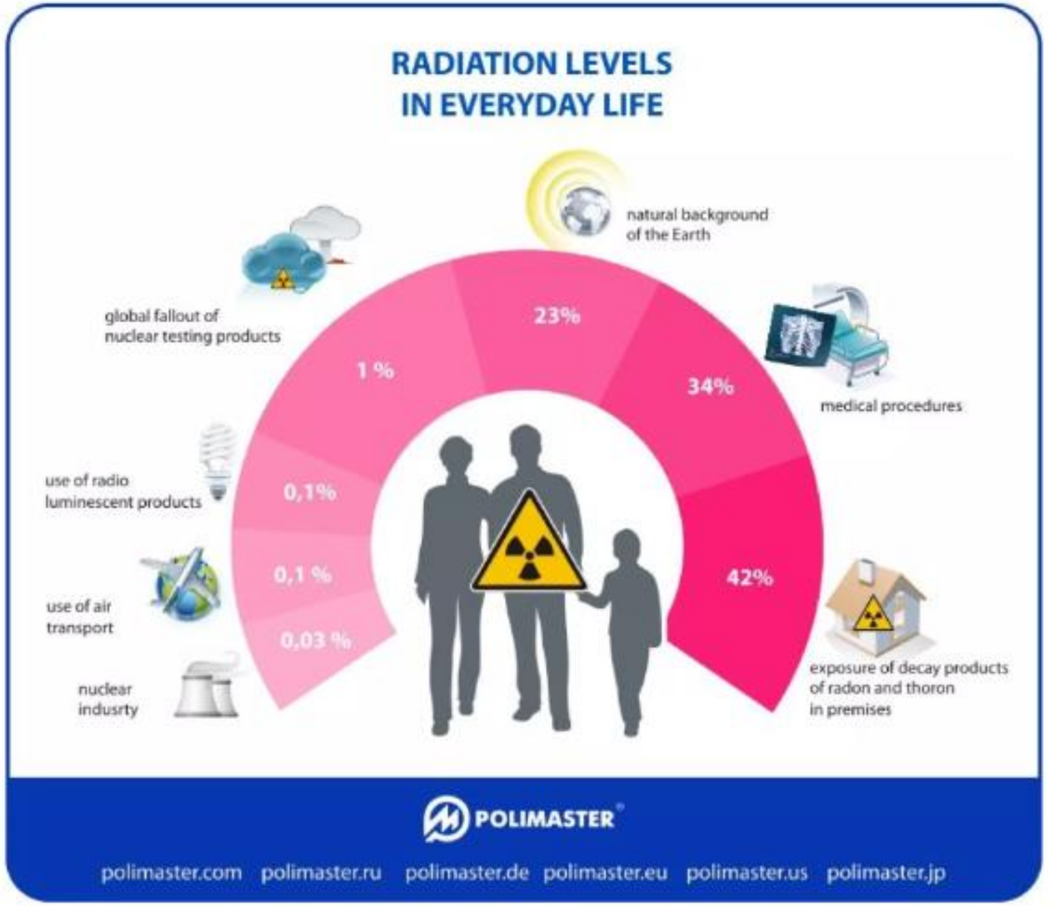
Radiation is a fact of life - all around us, all the time

The radiation pollution causes are various human activities, **that add to natural radiation background** (radiation produced everywhere in the **Universe in absence of human activities)**.

Radioactive pollution of the atmosphere can be defined as any undesirable change in the atomsphere due to increase in the natural background of radiation arising out of human activities involving the use of naturally occuring or artifically produced radioactive substances.

SOURCES OF RADIATION POLLUTION

1. Nuclear explosions and detonations of nuclear weapons
2. Defense weapon production
3. Mining
4. Nuclear accidents
5. research procedures and wastes
6. medical procedures and wastes
7. nuclear power plants
8. TVs
9. computers
10. radio waves
11. cell-phones .....



Sources of nuclear or radioactive waste

- LEGACY • Due to historic activities typically related to radium industry, uranium mining, and military programs, there are numerous sites that contain or are contaminated with radioactivity. • In the United States alone, the Department of Energy states there are "millions of gallons of radioactive waste" as well as "thousands of tons of spent nuclear fuel and material" and also "huge quantities of contaminated soil andwater".
- MEDICAL • Radioactive medical waste tends to contain beta particle and gamma ray emitters • Y- 90, used for treating lymphoma (2.7 days) • I-131, used for thyroid function tests and for treating thyroid cancer (8.0 days) • Sr-89, used for treating bone cancer, intravenous injection (52 days)
- MAN-MADE SOURCES• Exposure is mostly through medical procedures like X-ray diagnostics. • Radiation therapy is usually targeted only to the affected tissues.
- INDUSTRIAL • Industrial source waste can contain alpha, beta, neutron or gamma emitters. Gamma emitters are used in radiography while neutron emitting sources are used in a range of applications, such as oil well logging.
- COAL, OIL AND GAS • Coal contains a small amount of radioactive uranium, barium, thorium and potassium, but, in the case of pure coal, this is significantly less than the average concentration of those elements in the Earth's crust. • Residues from the oil and gas industry often contain radium and its decay products.

Sources of radioactive pollution

NUCLEAR FUEL CYCLE • It often contains radium and its decay products. • Uranium is used to make fuel from the reprocessing of used fuel. NUCLEAR FUEL CYCLE • The fission products removed from the fuel are a concentrated form of high-level waste as are the chemicals used in the process. • In the United States, this used fuel is usually "stored", while in other countries such as Russia, the United Kingdom, France, Japan and India, the fuel is reprocessed to remove the fission products, and the fuel can then be re- used.

NUCLEAR WEAPONS DECOMMISSIONING

Waste from nuclear weapons decommissioning is unlikely to contain much beta or gamma activity other than tritium and americium. It is more likely to contain alpha-emitting actinides such as Pu-239 which is a fissile material used in bombs, plus some material with much higher specific activities, such as Pu-238 or Po.

Natural sources

- NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM) • Substances containing natural radioactivity are known as norm • After human processing the waste becomes technologically enhanced becoming naturally radioactive material (TENORM). • A lot of this waste is alpha particle-emitting matter from the decay chains of uranium and thorium.
- The main source of radiation in the human body is potassium-40 • NORM is not regulated as restrictively as nuclear reactor waste, though there are no significant differences in the radiological risks of these materials.

TYPES OF RADIATION POLLUTION

CONTINUOUS RADIATION POLLUTION

Eg:
Workers in radioactive reactors

ACCIDENTAL RADIATION POLLUTION

Eg:
explosion of reactor

OCCASIONAL RADIATION POLLUTION

Eg:
Natural disaster

IMPACT OF RADIATION POLLUTION ON HUMAN HEALTH

INSTANTANEOUS EFFECT

- IMMEDIATE EFFECT

Eg:
hiroshima and nagasaki
(August 1945)
killed at least 129,000 people

PROLONGED EFFECT

- LONGER EFFECT

Eg:
hiroshima and nagasaki
Effecting 3rd generation

DELAYED EFFECT

- NO SYMPTOMS
- ADVERSE EFFECT

Eg:
Cancer

FACTORS INFLUENCING THE IMPACT OF RADIATION POLLUTION ON HUMAN HEALTH

- DOSE OF RADIATION OBSERVED BY THE BODY
- DURATION OF EXPOSURE
- SENSITIVITY OF THE PERSON

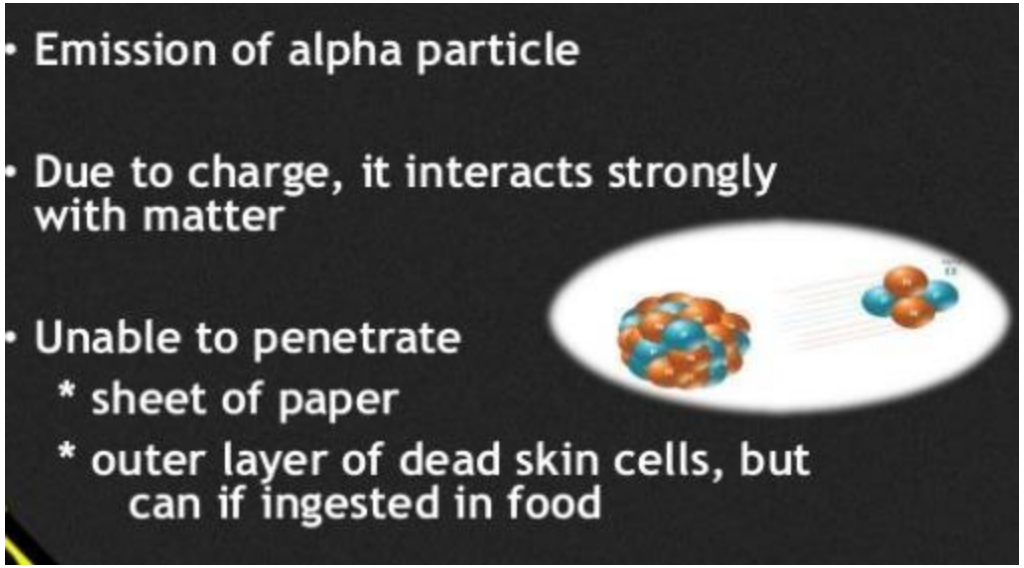
Exposure (rem)	Health Effect	Time to Onset (without treatment)
5-10	changes in blood chemistry	
50	nausea	hours
55	fatigue	
70	vomiting	
75	hair loss	2-3 weeks
90	diarrhea	
100	hemorrhage	
400	possible death	within 2 months
1,000	destruction of intestinal lining	
	internal bleeding	
	and death	1-2 weeks
2,000	damage to central nervous system	
	loss of consciousness;	minutes
	and death	hours to days

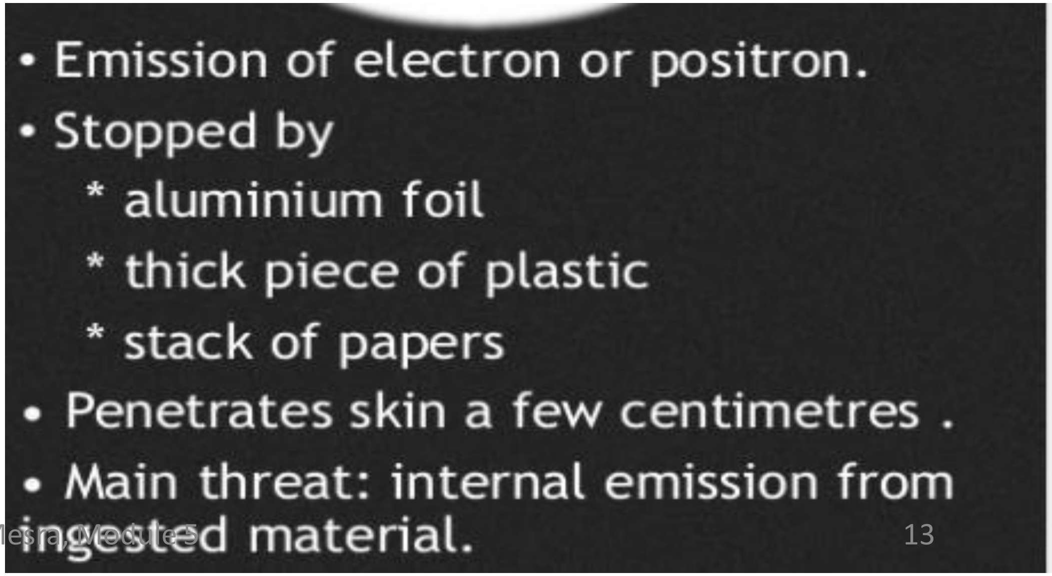
Radioactive emission damages DNA.
It can kill or deform the fetus.

The roentgen equivalent man (rem) is a CGS unit of equivalent dose, effective dose, and committed dose, which are dose measures used to estimate potential health effects of low levels of ionizing radiation on the human body.

Types of radiation

- **Alpha particles**, also called alpha rays or alpha radiation, consist of two protons and two neutrons bound together into a particle identical to a helium- 4 nucleus. They are generally produced in the process of alpha decay, but may also be produced in other ways.
- Composition: 2 protons, 2 neutrons
- Mass: 6.644657230(82)×10−27 kg;4.0015061...
- Electric charge: +2 e
- **Beta particles** (**β**) are high energy, high speed electrons (**β**$^-$) or positrons (**β**$^+$) that are ejected from the nucleus by some radionuclides during a form of radioactive decay called **beta**-decay. **Beta**-decay normally occurs in nuclei that have too many neutrons to achieve stability.

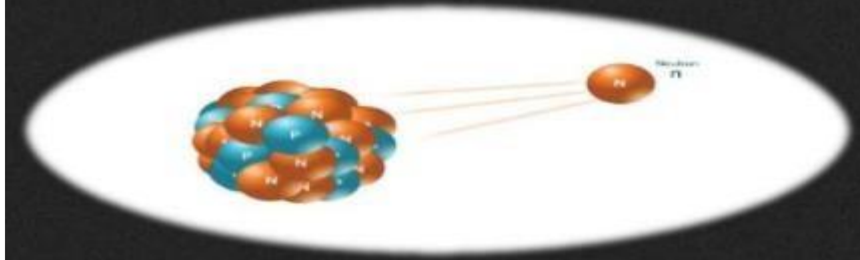




Gamma ray, electromagnetic radiation of the shortest wavelength and highest energy.

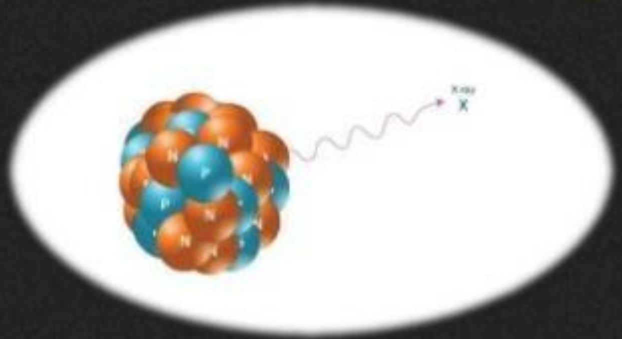
- Emission of high energy wave.
- Can penetrate into body.
- Can be stopped by lead or depleted uranium.
- The most energetic radiation.

Neutron Radiation



- Emission of neutrons
- Blocked by hydrogen rich material like concrete or water
- Does not ionize atom directly due to lack of charge
- Only radiation that turns other materials radioactive

X-Ray Radiation



- Similar to Gamma radiation
- Difference: originating from electon cloud instead of nucleus
- Has longer wavelength and lower energy than Gamma radiation

Nuclear Energy

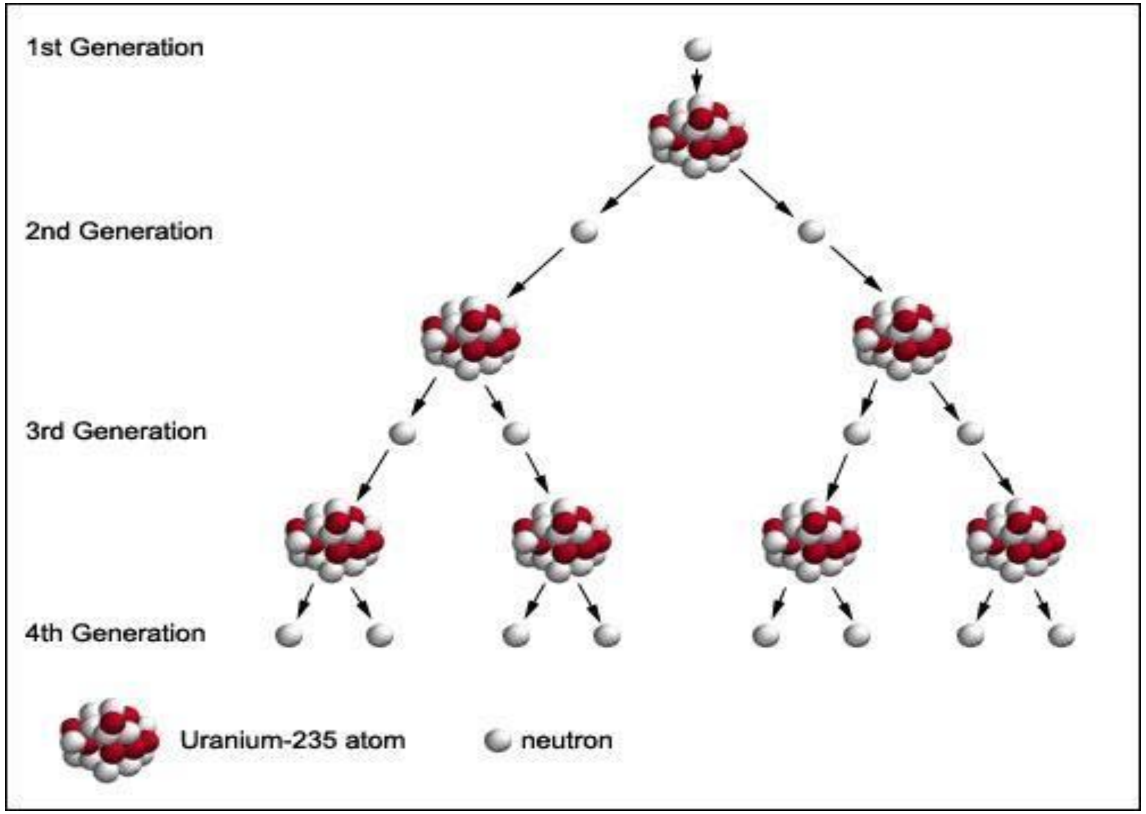
- **Nuclear fuel is any material that can be consumed to derive nuclear energy. The most common type of nuclear fuel is fissile elements that can be made to undergo nuclear fission chain reactions in a nuclear reactor**
- **The most common nuclear fuels are 235U and 239Pu. Not all nuclear fuels are used in fission chain reactions**

Uranium Is Mined and Refined

- **Uranium** is a chemical element with symbol **U** and atomic number 92.
- It is a silvery-white metal in the actinide series of the periodic table.
- A uranium atom has 92 protons and 92 electrons, of which 6 are valence electrons.
- Uranium is weakly radioactive because all its isotopes are unstable (with half-lives of the six naturally known isotopes, uranium-233 to uranium-238, varying between 69 years and 4.5 billion years).
- The most common isotopes of uranium are uranium-238 (which has 146 neutrons and accounts for almost 99.3% of the uranium found in nature) and uranium- 235 (which has 143 neutrons, accounting for 0.7% of the element found naturally).

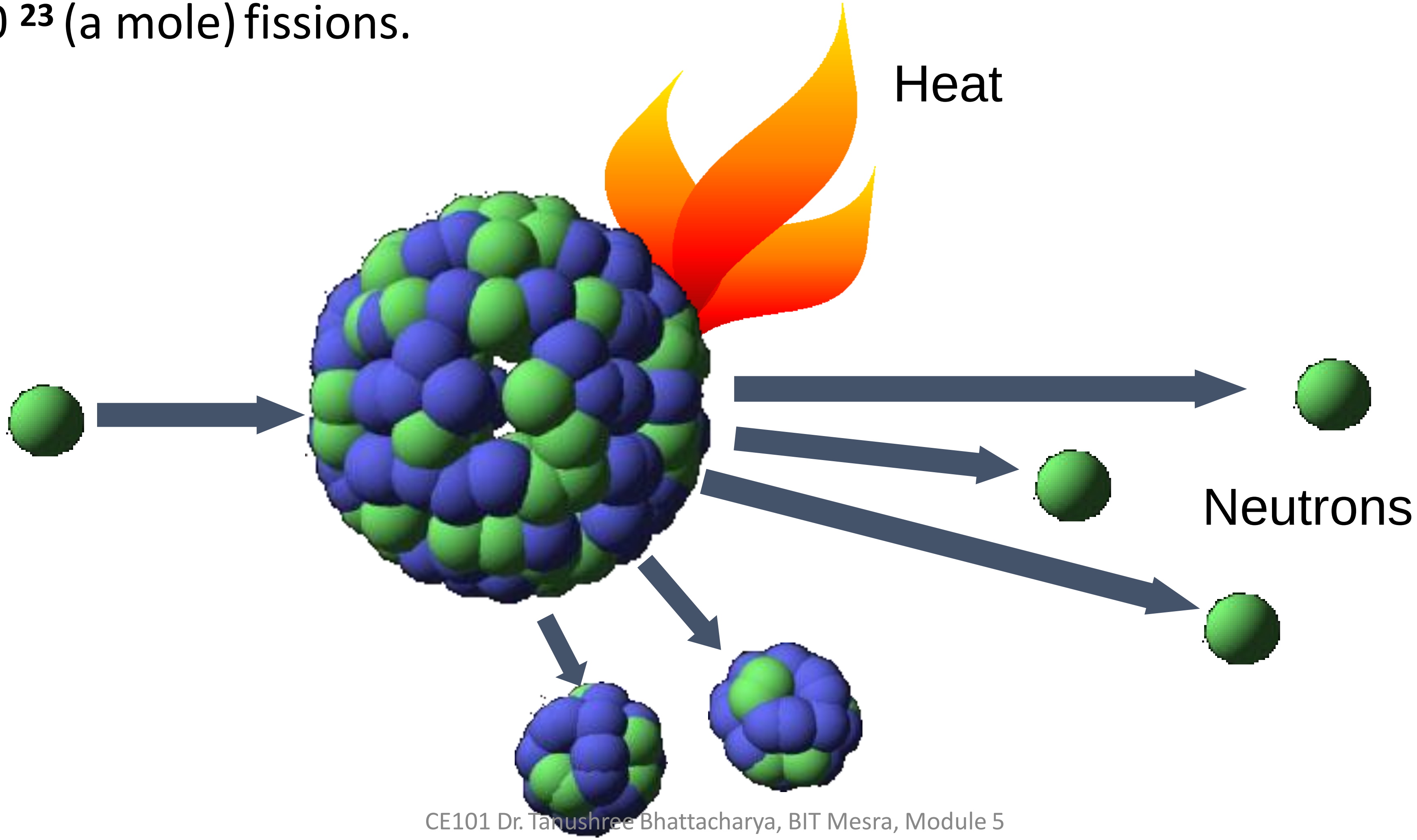
NUCLEAR FISSION

- When a neutron strikes an atom of the uranium, uranium splits into two atoms lighter and releases heat simultaneously.
- Fission of heavy elements is an exothermic reaction which can release large amounts of energy both as electromagnetic radiation and as kinetic energy of the fragments



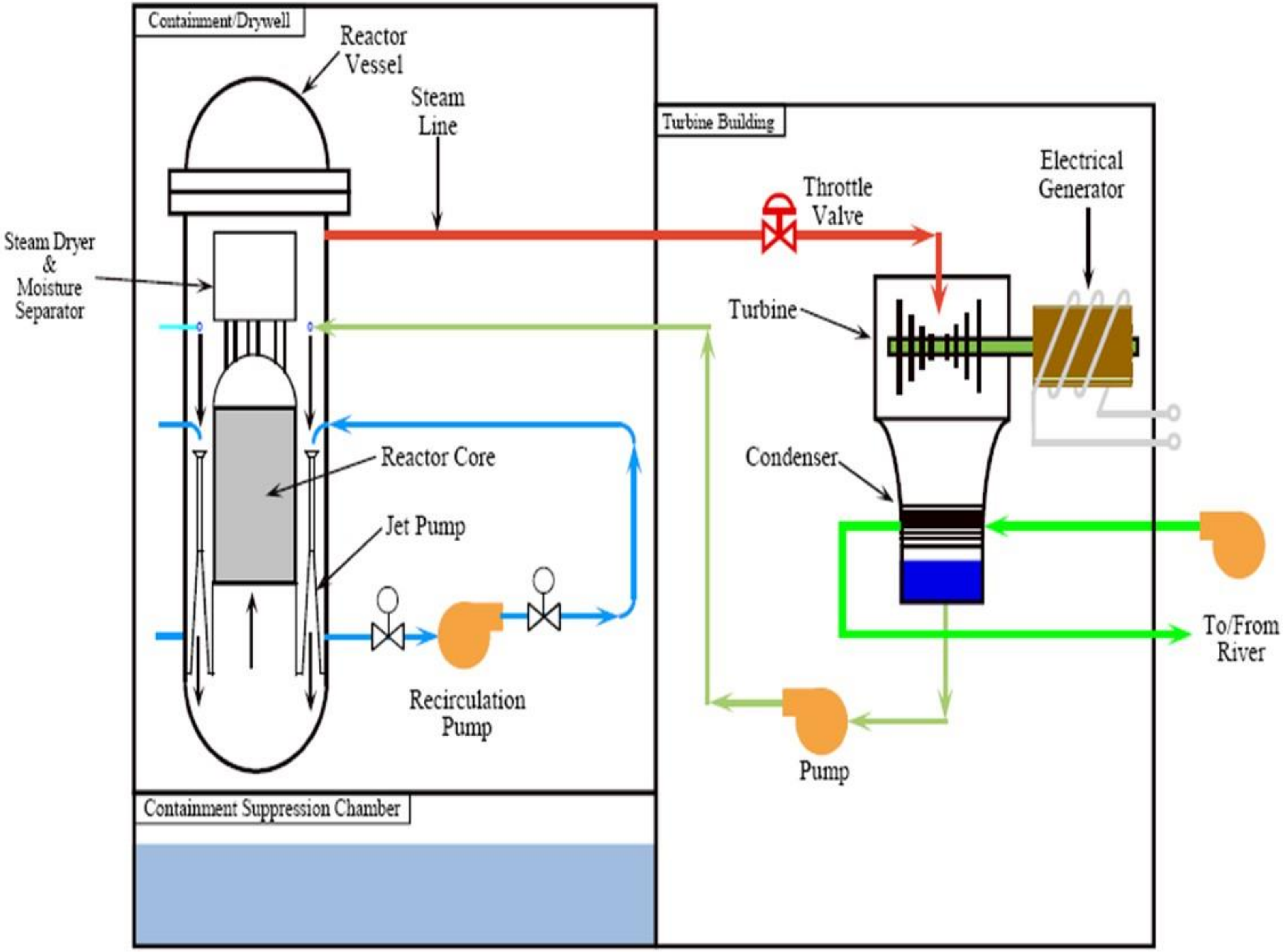
Splitting Atoms Releases Neutrons, Making Heat

- U**235** + n $\rightarrow$ fission + 2 or 3 n + 200 MeV
- If each neutron releases two more neutrons, then the number of fissions doubles each generation. In that case, in 10 generations there are 1,024 fissions and in 80 generations about 6 x 10 **23** (a mole) fissions.

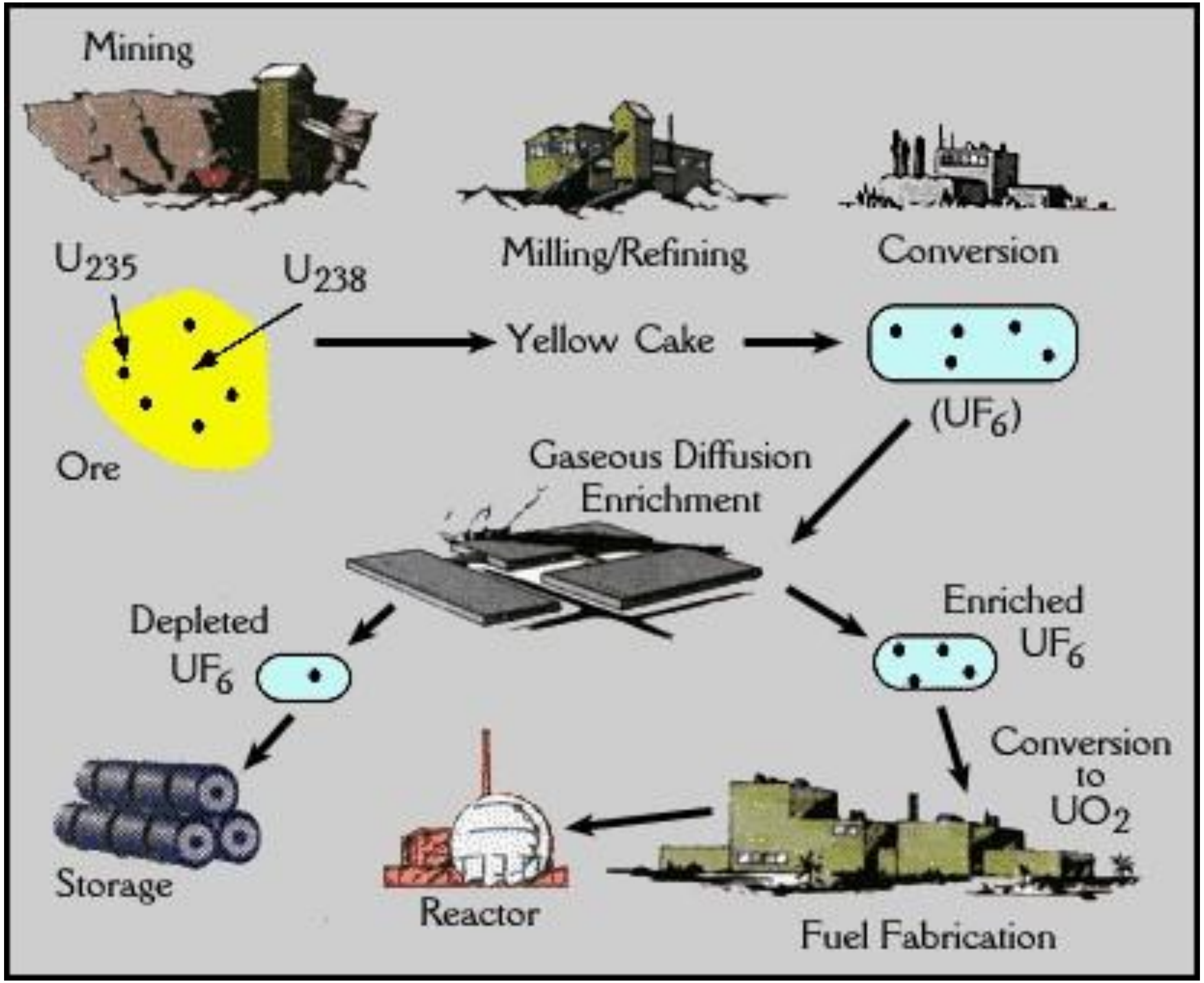


NUCLEAR REACTOR

A nuclear reactor is a device in which nuclear chain reactions are initiated, controlled, and sustained at a steady rate, as opposed to a nuclear bomb, in which the chain reaction occurs in a fraction of a second and is uncontrolled causing an explotion.



Uranium enrichment



Gaseous diffusion is a technology used to produce **enriched** uranium by forcing **gaseous** uranium hexafluoride (UF_6) through semi permeable membranes.

Enrichment Concentrates the Uranium Isotope

Uranium Is Encased in Solid Ceramic Pellets

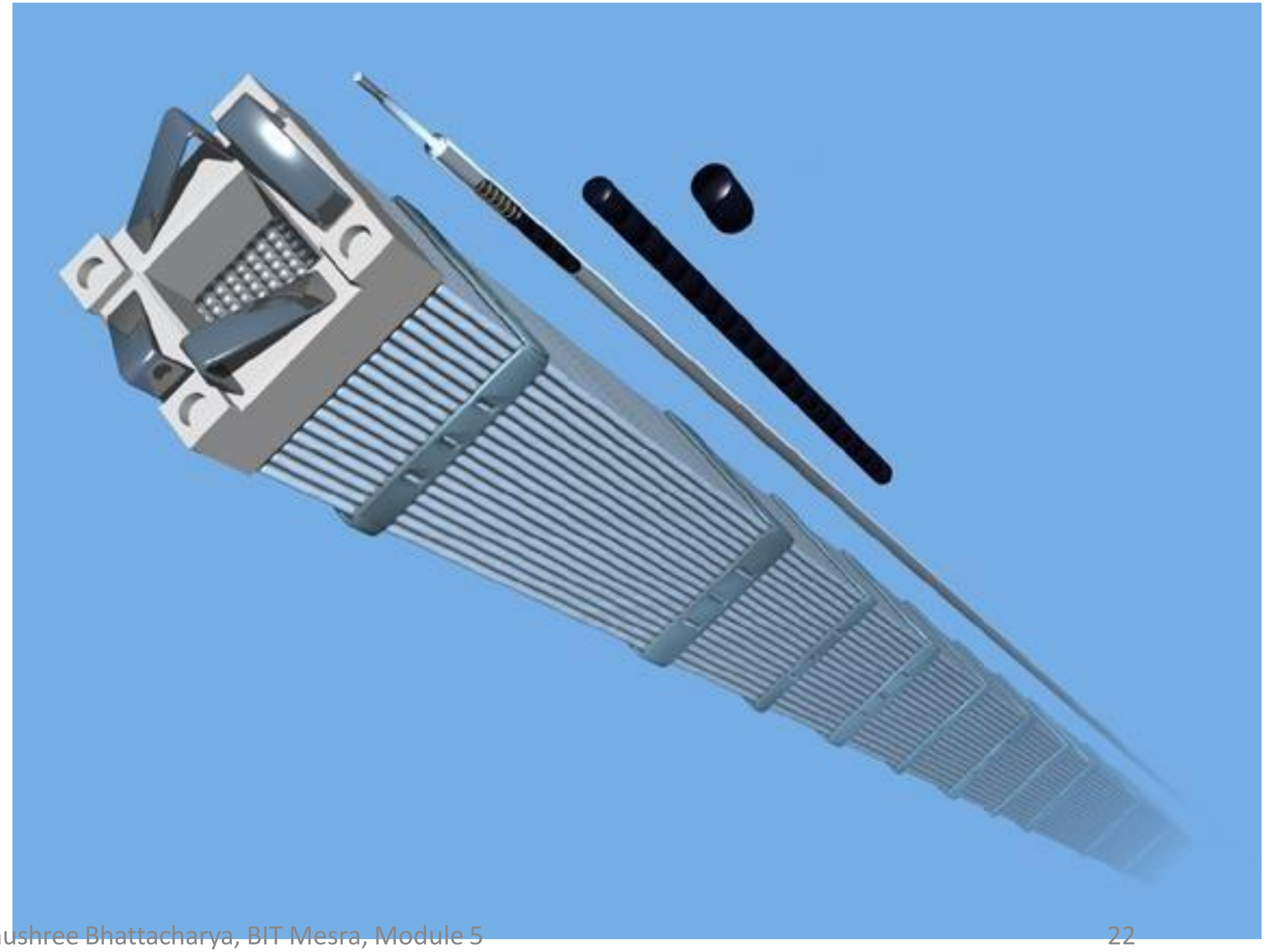
Milled uranium ore—U_3O_8 or "yellowcake"—is dissolved in nitric acid, yielding a solution of uranyl nitrate $UO_2(NO_3)_2$. Pure uranyl nitrate is obtained by solvent extraction, then treated with ammonia to produce ammonium diuranate ("ADU", $(NH_4)_2U_2O_7$). Reduction with hydrogen gives UO_2, which is converted with hydrofluoric acid (HF) to uranium tetrafluoride, UF_4. Oxidation with fluorine yields UF_6.

A process for conversion of gaseous UF_6 to UO_2 powders by using a fluidized bed reaction apparatus comprising pyrohydrolizing gaseous UF_6 and steam to obtain $UO_2\ F_2$ particles, hydrating and dehydrating the $UO_2\ F_2$ particles to UO_2F_2 anhydride and reducing the $UO_2\ F_2$ anhydride to UO_2 powders

Fuel Rods Filled With Pellets Are Grouped Into Fuel Assemblies

The Zircaloy tubes are about 1 cm in diameter, and the fuel cladding gap is filled with helium gas to improve the conduction of heat from the fuel to the cladding.

There are about 179-264 fuel rods per fuel bundle and about 121 to 193 fuel bundles are loaded into a reactor core. Generally, the fuel bundles consist of fuel rods bundled 14×14 to 17×17. PWR fuel bundles are about 4 meters long. In PWR fuel bundles, control rods are inserted through the top directly into the fuel bundle.

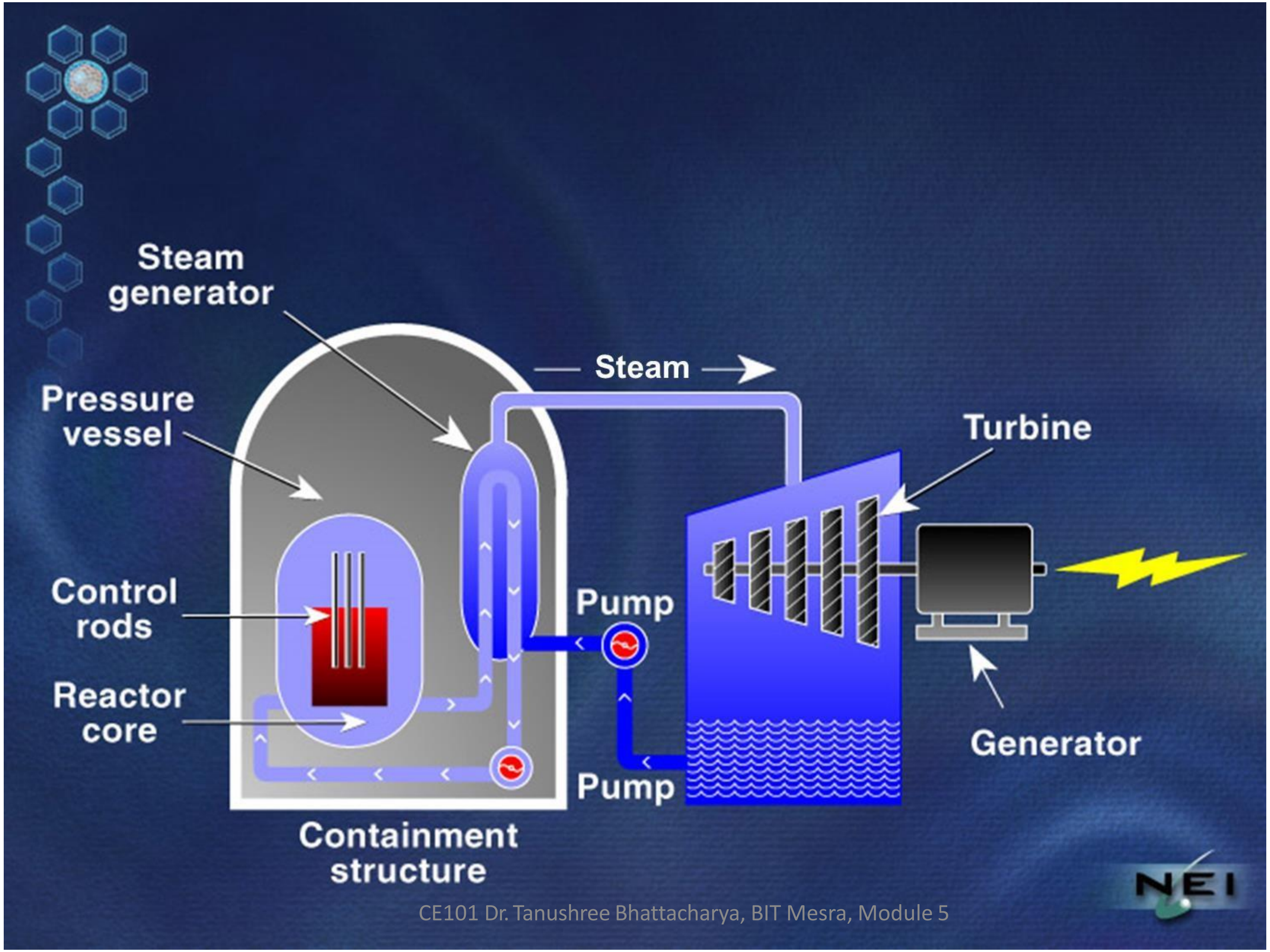


CONTROL RODS

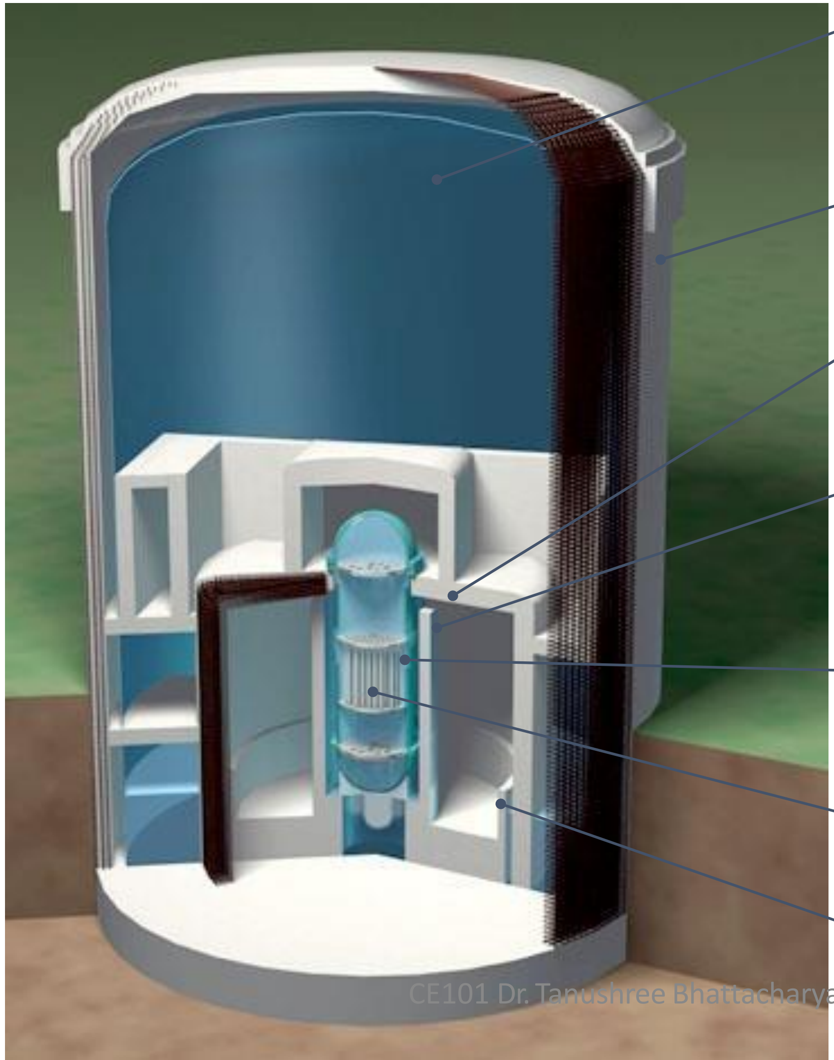
Control rods made of a material that absorbs neutrons are inserted into the bundle using a mechanism that can rise or lower the control rods.

The control rods essentially contain neutron absorbers like, boron, cadmium or indium.

Pressurized water Reactor



Safety Is Engineered Into Reactor Designs



Containment Vessel
1.5-inch thick steel

Shield Building Wall
3 foot thick reinforced concrete

Dry Well Wall
5 foot thick reinforced concrete

Bio Shield
4 foot thick leaded concrete with
1.5-inch thick steel lining inside and out

Reactor Vessel
4 to 8 inches thick steel

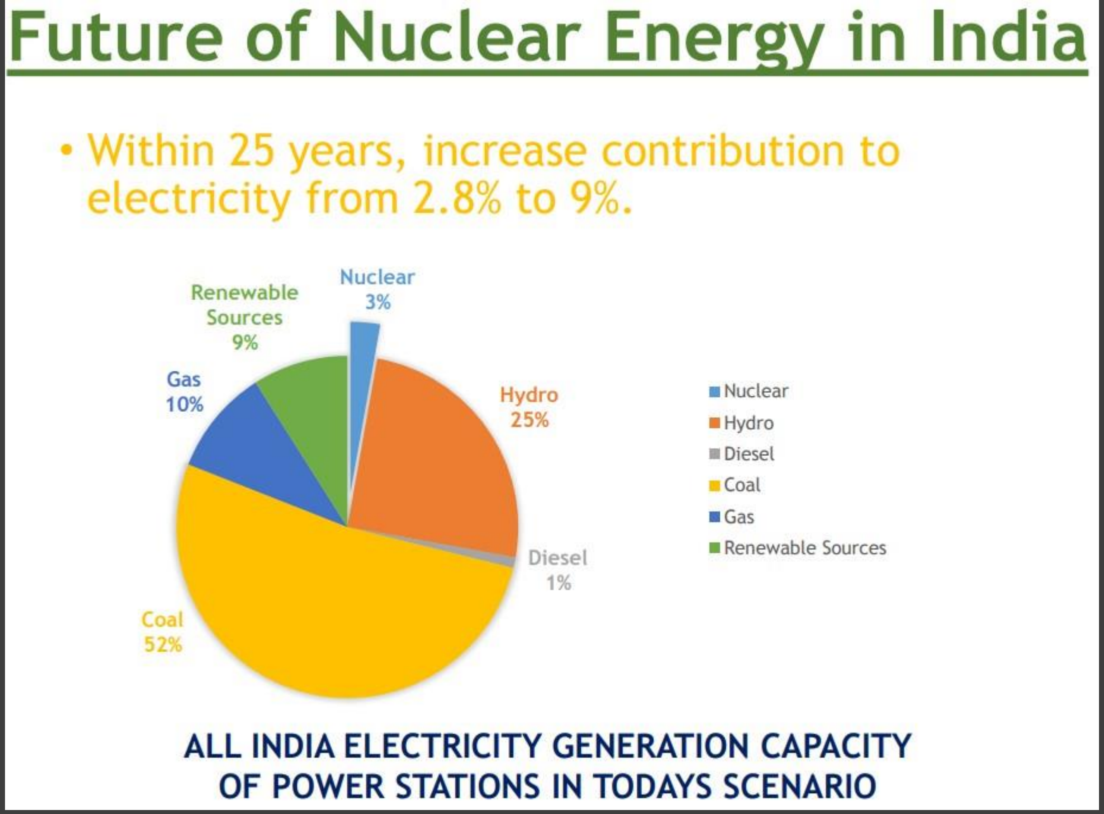
Reactor Fuel

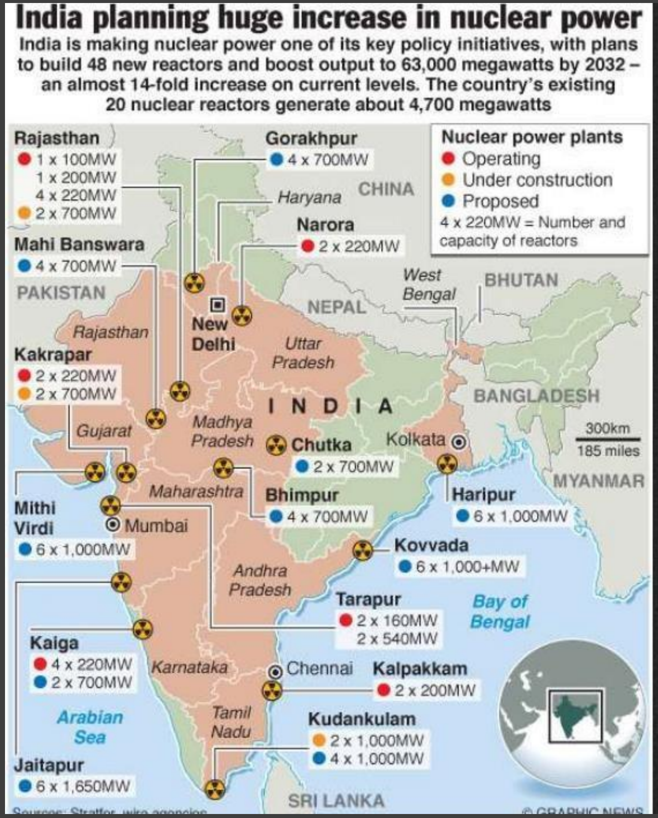
Weir Wall
1.5 foot thick concrete

Other parts

- **STEAM TURBINE**
- A a mechanical device that extracts thermal energy from pressurized steam, and converts it into useful mechanical . Various high-performance alloys and superalloys have been used for steam generator tubing.
- **COOLANT PUMP**
- The coolant pump pressurizes the coolant to pressures of the orderof 155bar. The pressue of the coolant loop is maintained almost constant with the help of the pump and a pressurizer unit.
- **FEED PUMP**
- Steam coming out of the turbine, flows through the condenser for condensation and recirculated for the next
- cycle of operation. The feed pump circulates the condensed water in the working fluid loop.
- **CONDENSER**
- Condenser is a device or unit which is used to condense vapor into liquid. The objective of the condenser are to reduce the turbine exhaust pressure to increase the efficiency and to recover high quality feed water in the form of condensate & feed back it to the steam generator without any further treatment.
- **COOLING TOWER**
- Cooling towers are heat removal devices used to transfer process waste heat to the atmosphere. Water cirulating throughthe codeser is taken to the cooling tower for cooling and reuse

Nuclear energy in India





- India has proposed new nuclear power plants in many states like
  - West Bengal (Haripur),
  - Andhra Pradesh (Kovvada)
  - Gujarat (Mithi Virdi)
  - Madhya Pradesh (Chutka,Bhimpur)
  - Haryana (Gorakhpour)
  - Tamil Nadu (Kundankulam)

Advantages

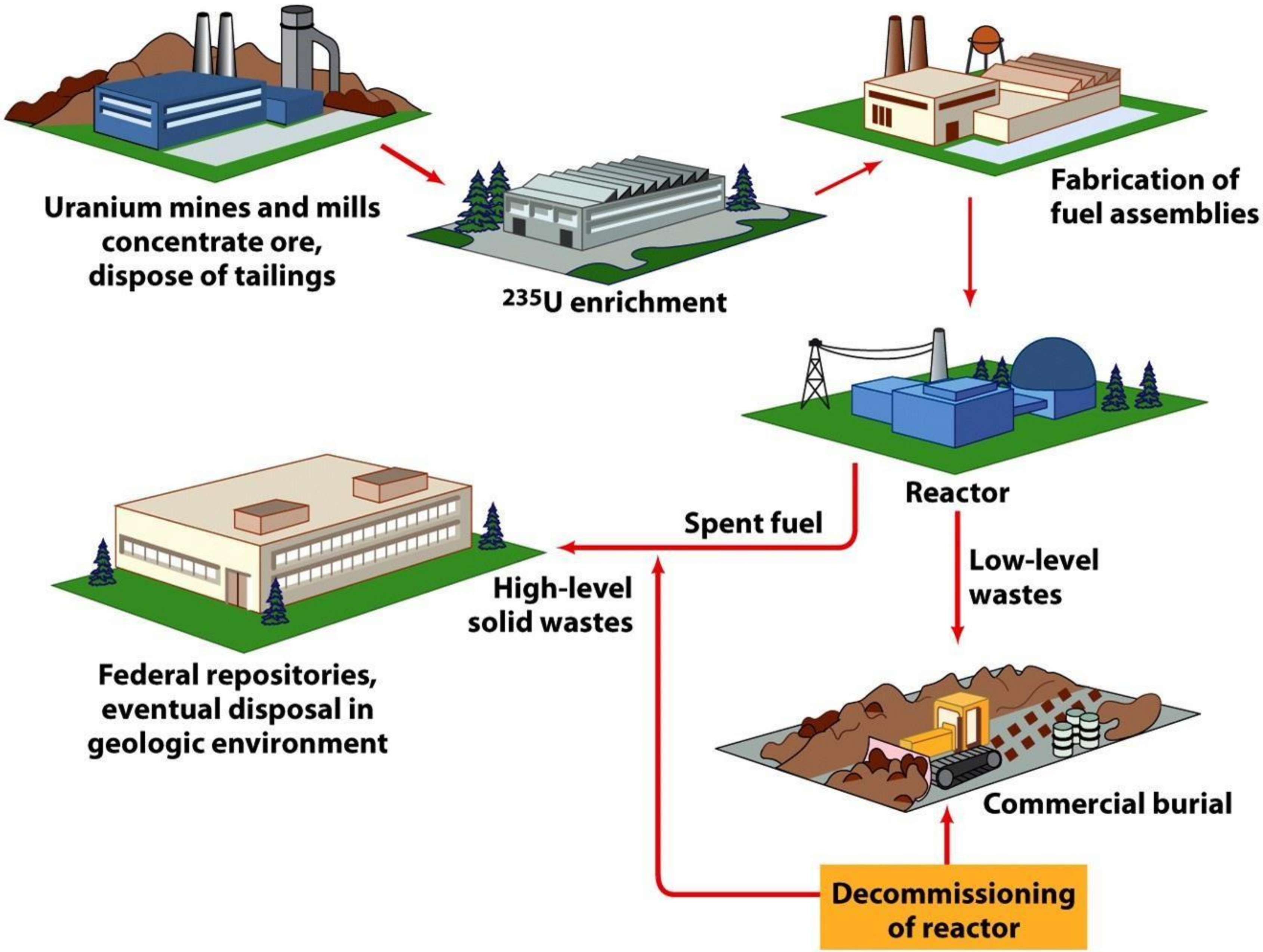
- Nuclear power generation does emit relatively low amounts of carbon dioxide (CO_2). The emissions of green house gases and therefore the contribution of nuclear power plants to global warming is therefore relatively little.
- This technology is readily available, it does not have to be developed first.
- It is possible to generate a high amount of electrical energy in one single plant

Disadvantages

- The problem of radioactive waste is still an unsolved one.
- High risks: It is technically impossible to build a plant with 100% security.
- The energy source for nuclear energy is Uranium. Uranium is a scarce resource, its supply is estimated to last only for the next 30 to 60 years depending on the actual demand.
- Nuclear power plants as well as nuclear waste could be preferred targets for terrorist attacks..
- During the operation of nuclear power plants, radioactive waste is produced, which in turn can be used for the production of nuclear weapons.

Environmental Problems associated with Nuclear PowerPlant

- Uranium mines and mills produce radioacitve waste material that can pollute the environment.
- U-235 enrichment and fabrication of fuel assemblies also produces waste materials.
- Dispersal of radioactive isotopes
    - Fallout
    - Can enter ecological food chain
    - Biomagnifies in the food chain (e.g. reindeer moss, caribou, humans)


Uranium mines and mills concentrate ore, dispose of tailings
235U enrichment
Fabrication of fuel assemblies
Reactor
Spent fuel
High-level solid wastes
Low-level wastes
Federal repositories, eventual disposal in geologic environment
Commercial burial
Decommissioning of reactor

Effects of radiations on human body

- A dose of 100 rems will cause some initial signs of **<u>radiation sickness</u>**, such as lossof white blood cells, nausea, vomiting, and **<u>headache</u>**.

- With a 300 rem dose there is temporarily hair loss , nerve cells and those that linethe digestive tract will be damaged.

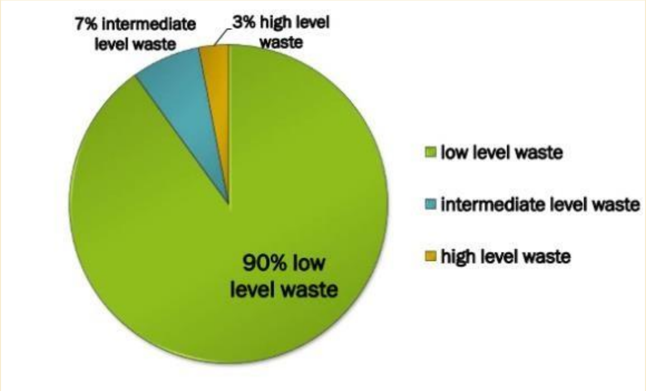
- As the dose rises and more white blood cells are lost, the human's immunesystem
- becomes seriously weakened.

- Exposure to radiation makes our bodies produce fewer blood clotting agents, called blood platelets, increasing our risk of internal bleeding. Any cut on the skin will take muchlonger to stop bleeding.
- •
- Experts say that approximately 50% of humans exposed to 450 rems will die, and 800 rems will kill virtually anyone. Death is inevitable and will occur from between two days to a couple of weeks.

Radioactive waste

- Continued development of nuclear fission as a source of energy is blocked
- by three main fears: potential reactor meltdown, proliferation of weaponizable fuel, and unsolved buildup of nuclear waste.
- As it turns out, the least progress has been made on addressing the waste issue!
- The concern with nuclear waste is its **radioactivity** - radioactive elements
- are unstable and can decay into other elements, releasing energy in the
- process. In some cases this energy can be threatening to humans or other life close enough to be exposed to the radiation.
- Waste is categorized according to two metrics - the **danger** it poses, and the **lifetime** over which it remains dangerous.
- Some radioactive waste is a byproduct of medical and research efforts, but the majority is produced through nuclear fission in reactors.

Radioactive waste Management



- Low Level Waste • Low level waste (LLW) is generated from hospitals and industry, as well as the nuclear fuel cycle. • Materials that originate from any region of an Active Area are commonly designated as LLW • LLW is suitable for shallow land burial
- Intermediate level waste • Contains higher amounts of radioactivity and in general require shielding, but not cooling • Includes resins, chemical sludge and metal nuclear fuel cladding, as well as contaminated materials from reactor decommissioning. • It may be solidified in concrete or bitumen for disposal.
- High Level Waste • HLW is produced by nuclear reactors. • HLW worldwide is currently increasing by about 12,000 metric tons every year • In 2010, there was very roughly estimated to be stored some 250,000 tons of nuclear HLW • that the main proposed long-term solution is deep geological burial, either in a mine or a deep borehole.

Waste solutions

- Several solutions have been proposed and enacted for dealing with nuclear waste. In a 'closed' fuel cycle, the spent fuel from a reactor is reprocessed to extract the remaining usable elements. The unusable radioactive waste is left behind in a more concentrated (usually liquid) form. In contrast, the 'open' fuel cycle does not reprocess spent fuel so while it contains much the same spectrum of radioactive elements, they constitute only a small amount of the total mass, and the fuel is left solid.
- In either form, the waste produced contains the same radioactive elements that have to be dealt with. Initially, **the waste is so highly radioactive that it can kill in minutes and some of the radioactivity heats it to high temperatures**.
- It is usually put in **'interim' storage, often in sealed containers that are kept underwater to cool it down**. While this isn't ideal and the storage must be kept under surveillance, simply waiting for a few years will decrease the waste's potency.
- By then, the most radioactive **'short-lived' elements will have mostly decayed, and the truly problematic elements remain**. They include both long-lived fission products and actinides, seen in Table 1. In waste that hasn't been reprocessed, there is also a considerable amount of plutonium (a TRU) in different isotopes, all radioactive.

Table 1: - *The most concerning elements in nuclear reactor waste (spent fuel)*

Element	Half-life (years)	Type	Percent of Fuel
Sr-90	~30	Fission Product (FP)	0.04
Cs-137	~30	FP	0.09
Tc-99	~10^6	FP	0.09
I-129	~10^7	FP	0.03
Np-237	2.0×10^6	Transuranic (TRU)	0.05
Am-241	400	TRU	0.01

Solutions…

- There are two options to avoid the threat of the longer-lived radioactive elements. One is to wait until they decay into stability, the same strategy as is used during **the interim storage**.
- However, current interim storage isn't suitable for the much longer timescales necessary for waste to become safe. As a result, the concept of 'geologic' storage has been proposed, in which large amounts of waste are stockpiled and sealed away for millions of years, with a thick layer of rock (hence the name) separating them from us. With thousands of tons of nuclear waste, the United States has investigated storage in Yucca Mountain since 1982, but little progress has been made and in the meantime the waste remains in interim situations that weren't meant to be used for decades.
- Geologic storage promises a very long wait, however, and the prospect of continually searching for and filling new repositories as more waste is produced.
- The other option is to **accelerate the change of dangerous waste into more benign elements by transmuting** it with more neutrons. A fission reactor is unsuitable for this purpose because the waste acts as a 'poison' preventing chain reactions from occuring. Other sources of neutrons are possible, however, including those from nuclear fusion and created by particle accelerators. The last is known as 'accelerator transmutation of waste' (ATW) and is being investigated as an alternative to the geologic storage solution.

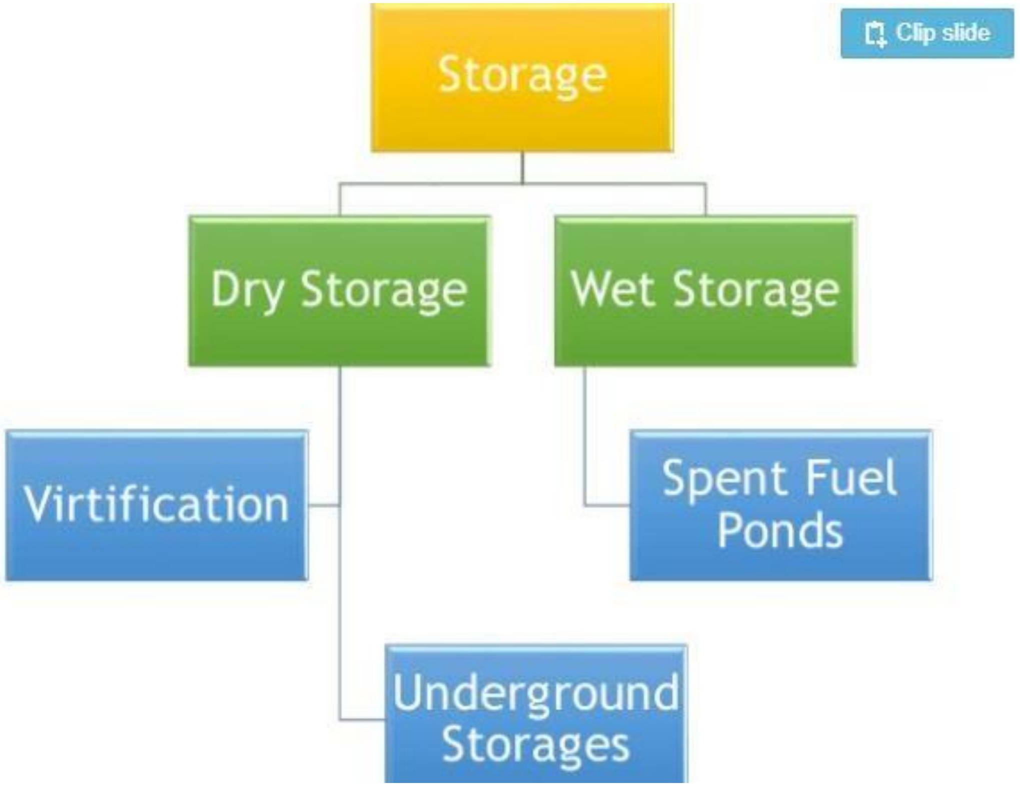
Storage

•Storage • One of the major issues is storage • Can be stored in ground, ejected in space, disposed in ocean or disposed in ice sheets.

•Affects on Nature • Have huge environmental impacts on plant and animal species. • Can cause cancerous growths, for instance, or causing genetic problems.

• Storage of Radioactive Waste

•Storage of Spent Fuel • Two different strategies are used for spent nuclear f�el: Reprocessing for new fuel�Storing for future needs • France, China, India, Japan, Russia reprocesses the fuel. • USA, Finland, Sweden, Canada have opted for direct disposal.



Storage

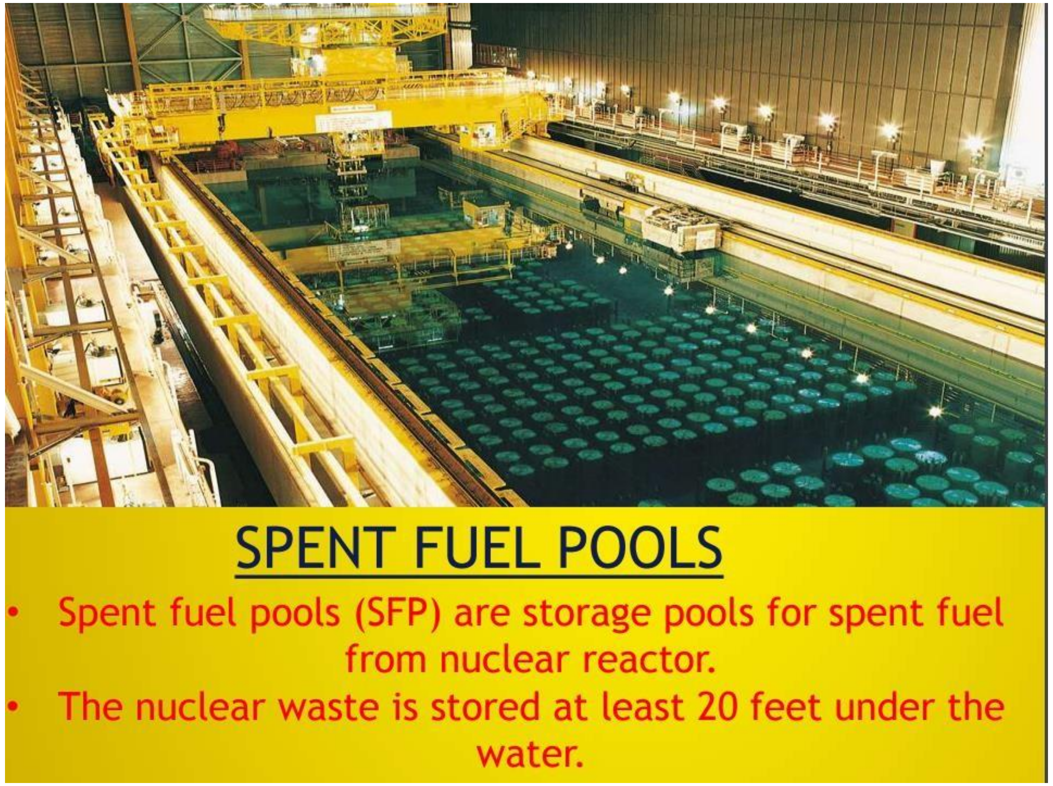

Underground Storage
A Storage tank, not including any underground piping connected to the tank.
Having 10% of its volume underground


Underground Storages in World
Kalpakkam , India
Olkiluoto, Finland - Largest repository
Yucca mountain, USA
Gyeognju , South Korea
Forsmark, Sweden
France, Belgium & Switzerland have experimental sites.

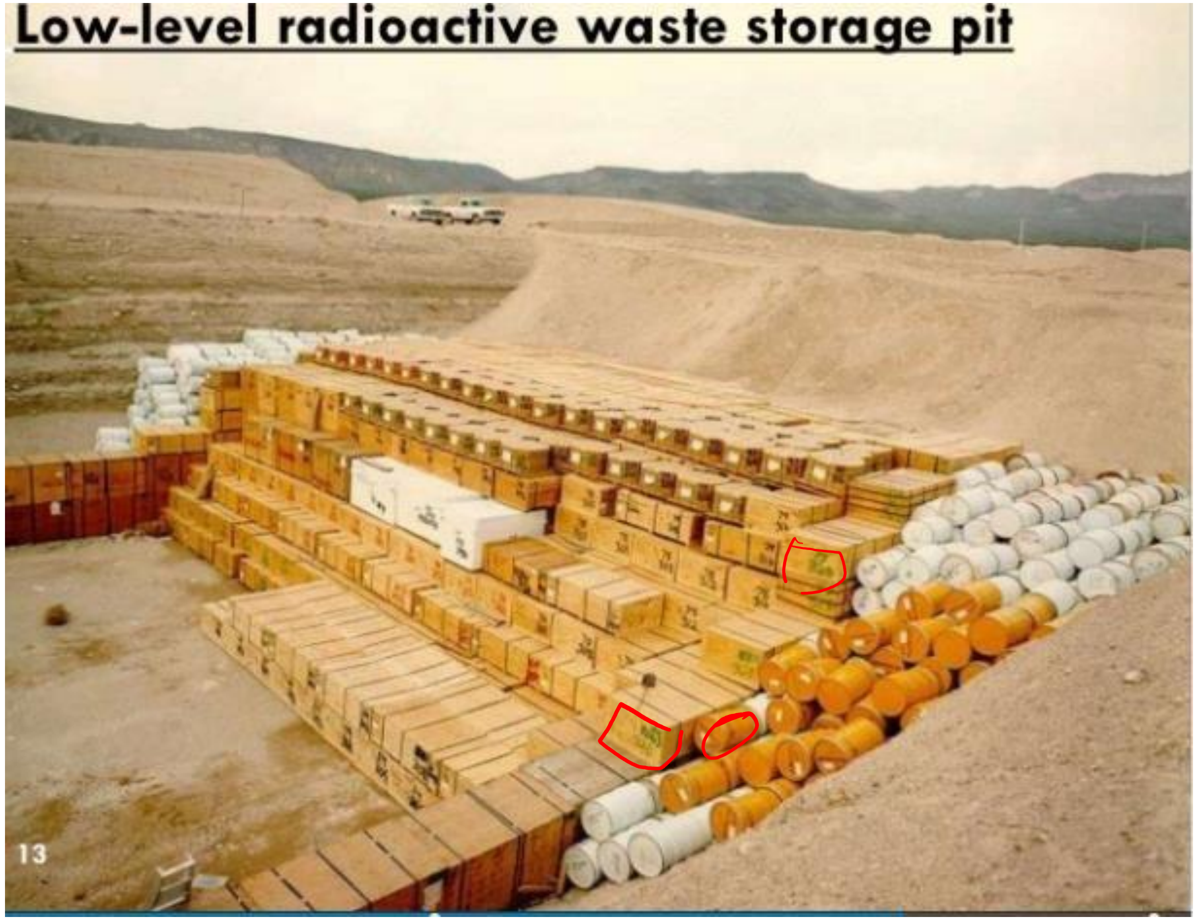
Storage

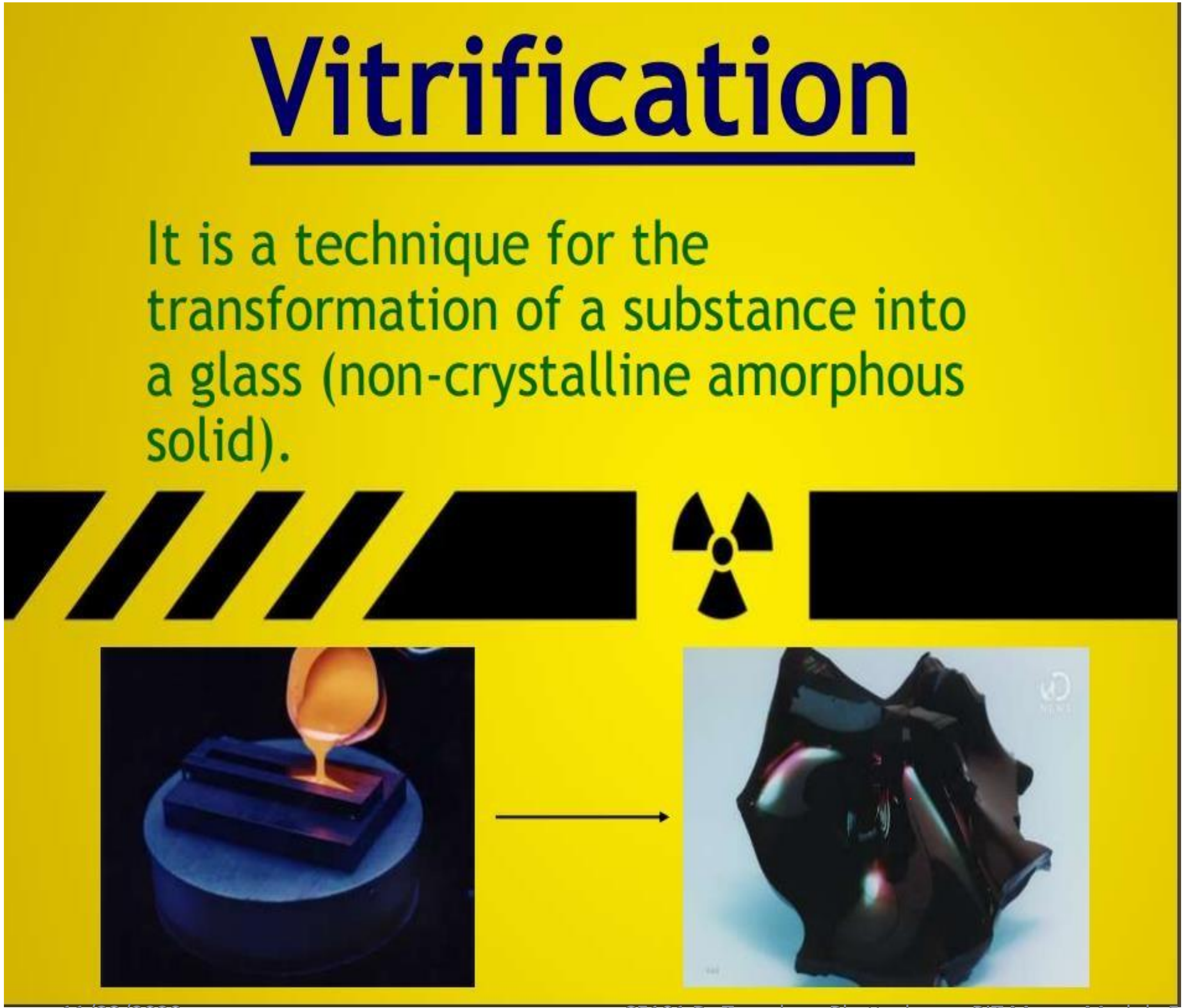
•Storage of Spent Fuel • Store waste in only approved bags and container. • Bags – Yellow with Radiation label • Boxes – Line with Yellow bag • Bottles – Attach Radiation label •

•DO NOT use anything that can be mistaken for an ordinary trash container • DO NOT use coke bottles , milk bottles and etc. for liquid waste.



Above ground storage and near surface storage

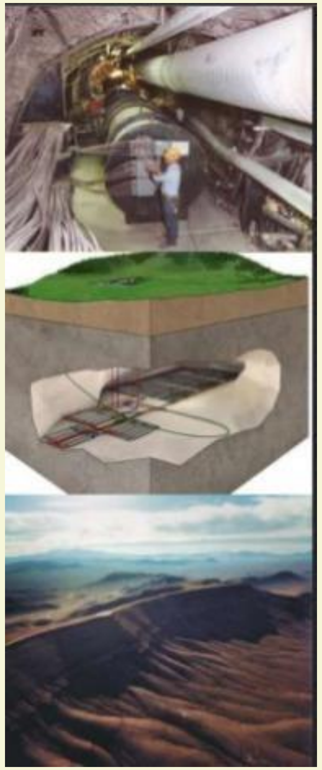




Vitrification It is a technique for the transformation of a substance into a glass (non-crystalline amorphous solid). Vitrification • Borosilicate glass is mainly used as medium for dealing with High Level Waste • The solidified waste is stored in stainless steel containers • Principle aims are:

i. Minimise the volume of waste ii. Reduce potential hazard by conditioning it into solid form

RADIOACTIVE DISPOSAL AND MANAGEMENT



• Waste disposal is discarding waste with no intention of retrieval. •Waste management means the entire sequence of operations starting with generation of waste and ending with disposal. Disposal & Management

Methods

•Deep geological repositories Ocean dumping • Seabed burial • Sub-seabed disposal • Subductive waste disposal method • Transforming radioactive waste to non-radioactive stable waste • Dispatching to the Sun • Legal methods of waste disposal

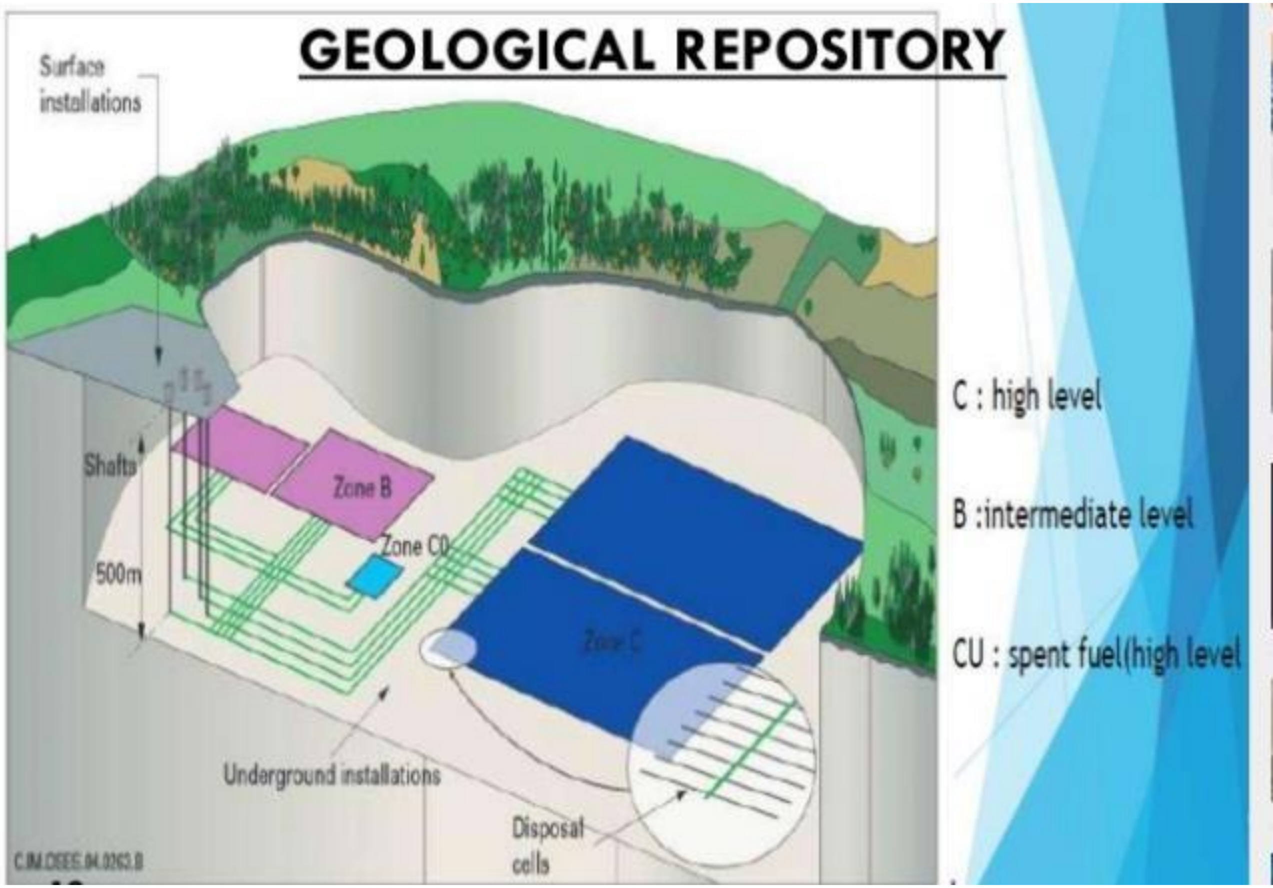
Methods Geological Disposal Ocean Dumping Subductive Method Transmutation Method Other ways

GEOLOGICAL DUMPING • Disposal in a facility constructed in tunnel, vaults or silos in a particular geological formation at least a few hundred meters below ground level. • Such a facility could be designed to accept high level radioactive waste (HLW), including spent fuels if it is to be treated as waste. • Yucca Mountain in USA is the recent of geological dumping.

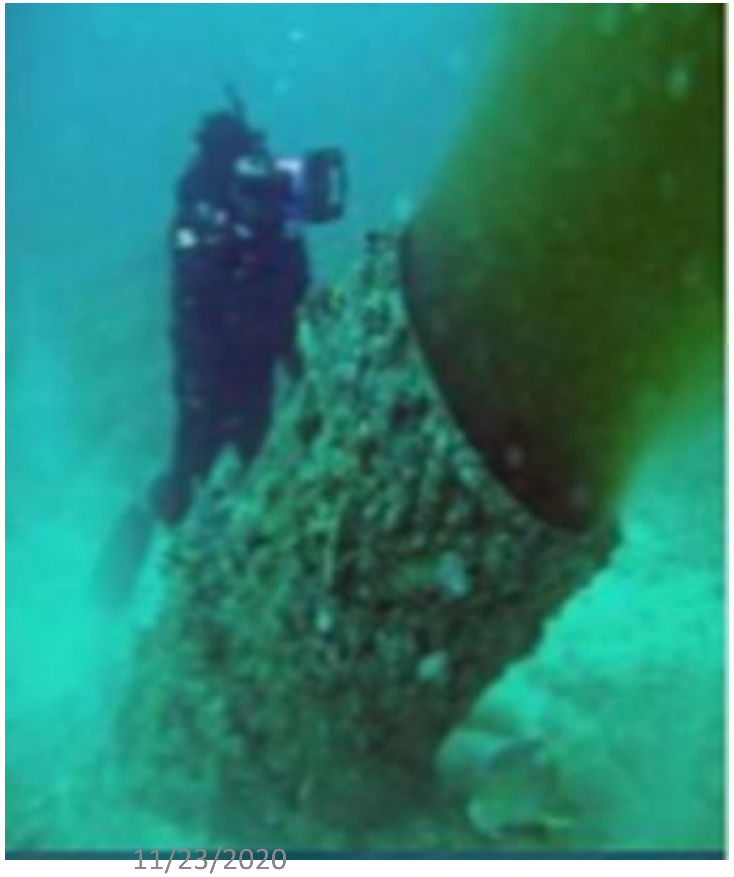
GEOLOGICAL DUMPING • Geological dumping means disposal of nuclear waste under continental crust or under seabed. • It provides natural isolation system that is stable over thousands of years to contain long lived radioactive waste. • Low level radioactive waste (in near surface facilities or old mines) • High level radioactive waste (in host rocks that are crystalline or argillaceous)

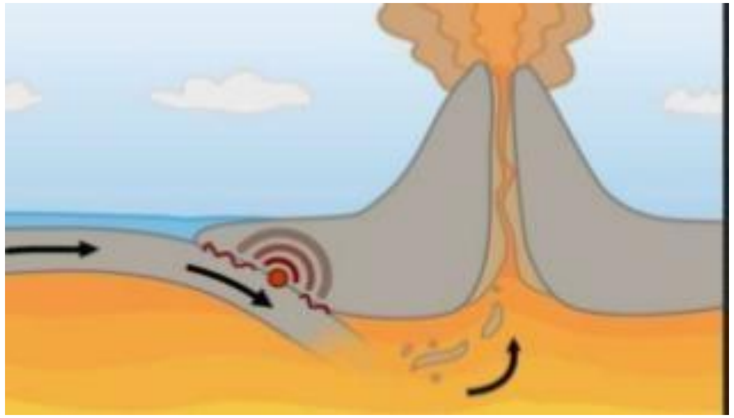
Deep Boreholes

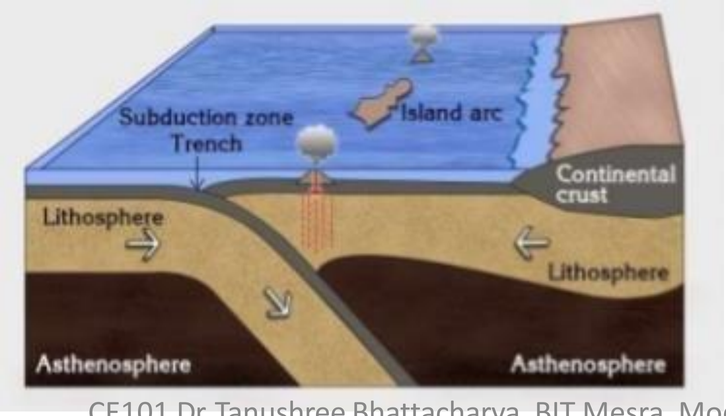
- Similar concept to basic geological repositories
- Kilometers deep rather than hundreds of meters
- Provide Further isolation from ground water
- More potential borehole locations around the globe
- Can be created in many cases close to power plants



Dumping ….







- OCEAN DUMPING • OCEAN DUMPING is the dumping or placing of material in the ocean , often on the continental shelf. • A wide range of materials is involved, including garbage, construction and demolition debris, sewage sludge, dredge material, waste chemicals, nuclear waste. • Sometimes hazardous and nuclear waste are also disposed but these are highly dangerous for aquatic life and human life also.

- Ocean dumping (good alternative and least expensive method) • In this method nuclear waste is dumped into the ocean. • For many years the countries like U.S.A. ,U.K.,FRANCE etc. Adopted this method. • Banned by most of the countries due to scientific proof of bad effects on ocean and marine life. • But Russia continue to dispose of its waste into ocean. Because it has no other alternative method.

- SUB SEABED DISPOSAL• Seabed disposal is different from sea dumping. The floor of deep oceans is a part of tectonic plates covered by hundreds of meters of thick sedimentary soft clay. • The high-level radioactive waste contained in canisters, would be lowered into these holes and stacked vertically one above the other interspersed by 20 m or more of mud pumped in.

- Sub-ductive waste disposal method • It is one of the single viable disposal method which ensures NON RETURN of regulated material to biosphere

• Subduction is process where one tectonic plate slides beneath another and is eventually reabsorbed into mantle • It forms high level radioactive waste in a subducting plate where it will be dispersed through mantle.

Accelerator transmutation of waste' (ATW)

- The basic concept of ATW is simply to 'finish the job' of burning or transmuting the radioactive waste through intense neutron flux, thereby drastically reducing its radioactivity. Again, bombardment with large numbers of neutrons is considered as a way to either fission the heavier elements into less dangerous species or convert the lighter ones through absorption. A particle accelerator can be used as a source of high-energy protons, which can then be used to create neutrons through a process known as 'spallation.' This occurs when a proton collides with a heavy nucleus in the spallation target, after which the nucleus ejects a large number of neutrons proportional to the energy of the original proton.
- However, advances both in the technology needed to accelerate the protons and the understanding of spallation physics have prompted investigation of accelerator-created neutrons for waste treatment.
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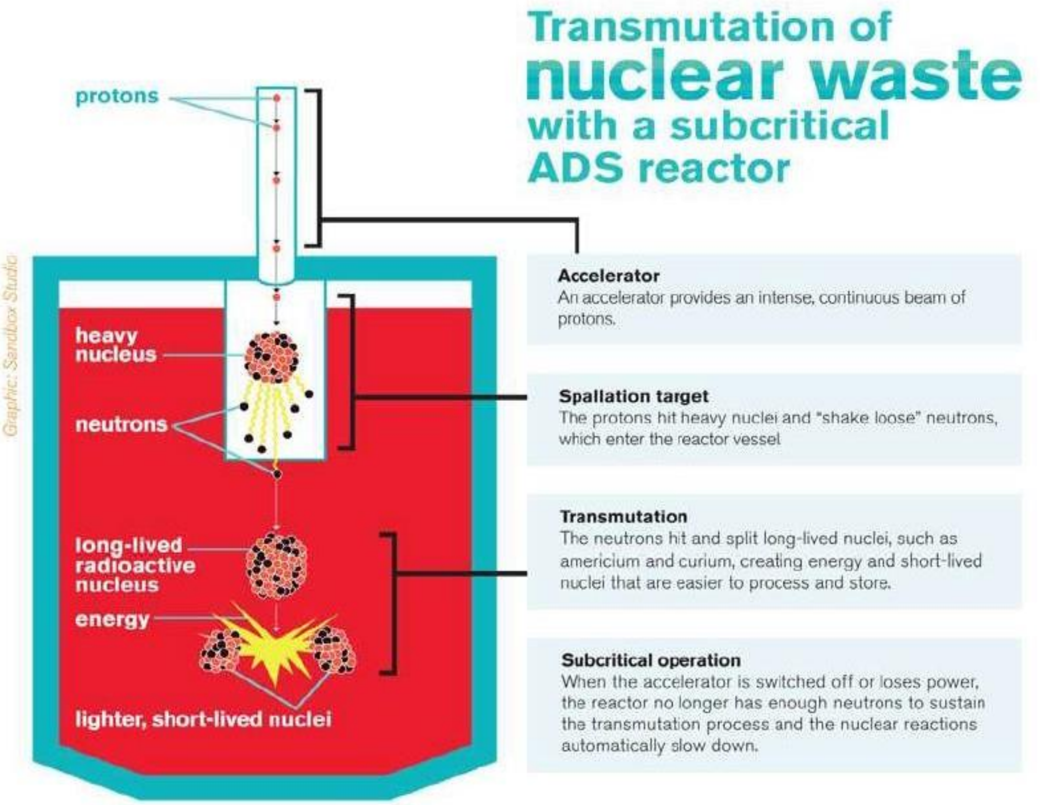


While doing so may create further radioactive elements both in the spallation target and in the bulk of the waste, by eliminating the long-lived ones from Table 1 above ATW can theoretically change the nature and the timescale of the problem considerably.

The question is, how many and what kind of neutrons are necessary for effective transmutation? The answer depends on the **cross sections of the waste elements, where cross section relates to the probability to absorb or fission** when hit by a neutron of a given energy. **For a low cross section, one must generate more neutrons and use more energy to transmute the offending element**. The TRU elements remaining in the waste are generally fairly easy to fission, but the threatening FP's usually have much lower cross sections for the desired neutron absorption that can transmute them into a more benign state. These elements present a greater concern than the TRUs because they can easily contaminate water and so leaks of radioactive waste can spread much more quickly if they include long-lived FP's.

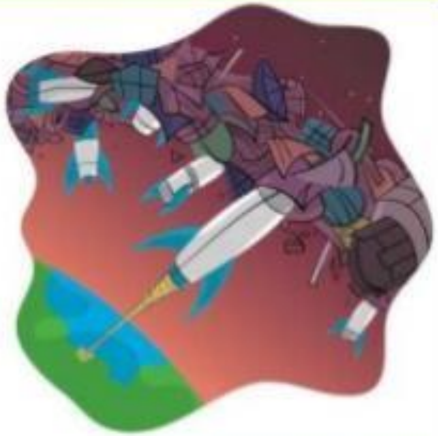
Element	Half-life (years)	Type	Percent of Fuel
Sr-90	~30	Fission Product (FP)	0.04
Cs-137	~30	FP	0.09
Tc-99	$\sim 10^6$	FP	0.09
I-129	$\sim 10^7$	FP	0.03
Np-237	2.0×10^6	Transuranic (TRU)	0.05
Am-241	400	TRU	0.01

Table 1: - The most concerning elements in nuclear reactor waste (spent fuel).

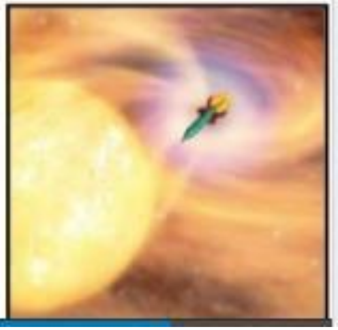
Space dumping

Launch it into Space

- Near infinite storage space
- Completely removes waste from biosphere



- Technical risks and problems
- High risk of space vehicle failure
- Relatively limited volume per launch
- High energy cost of space launch
  - The current cost to launch an object into orbit around the earth is about $20,000 per kilogram.
- Beamed energy technology (BEP)



RADIOACTIVE DIAMOND BATTERIES

-MAKING GOOD USE OF NUCLEAR WASTE

- Developed by University of Bristol
- Diamond is made from **carbon- 14** (radioactive) extracted from nuclear waste

-Generates a small magnetic current when subjected to radiation field

Advantages

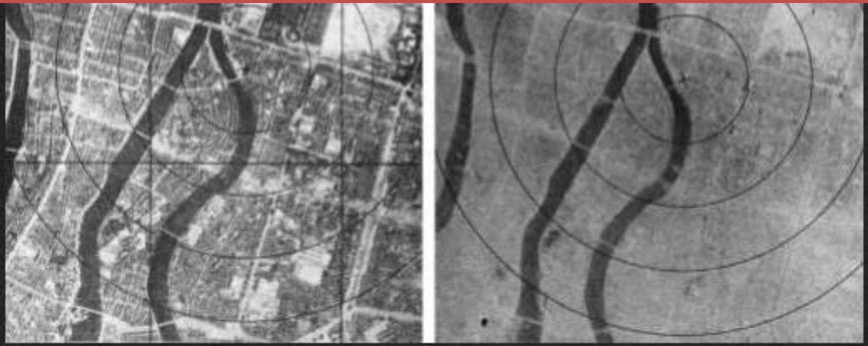
- No moving parts involved
- No emissions generated
- No maintenance required
- Continuous power output
- Low power and extremely long life
- Cost to produce diamond<< Cost to dispose nuclear waste
- Can be used where batteries could not be replaced such as pacemakers, in spacecrafts and satellites

Causes of Nuclear Disaster

Nuclear disasters are usually associated with meltdowns. When a meltdown occurs in a reactor, the reactor "melts". That is, the temperature rises in the core so much that the fuel rods actually turn to liquid, like ice turns into water when heated. If the core continues to heat, the reactor would get so hot that the steel walls of the core would also melt. In a complete reactor meltdown, the extremely hot (about 2700 Celsius) molten uranium fuel rods would melt through the bottom of the reactor and actually sink about 50 feet into the earth beneath the power plant.

The molten uranium would react with groundwater, producing large explosions of radioactive steam and debris that would affect nearby towns and population centers.

ATOMIC BOMB MUSHROOM CLOUDS OVER HIROSHIMA AND NAGASAKI



- Within the first two to four months of the bombings, the acute effects of the atomic bombings killed 90,000–146,000 people in Hiroshima and 39,000–80,000 in Nagasaki.
- Most of the deaths happened in the first day.

THREE MILE ISLAND ACCIDENT

Location: Three Mile Island Nuclear Generating Station, Londonderry Township, Pennsylvania, United States

- In the early morning hours of March 28, 1979, a mechanical or electric failure set off an unlikely series of events that led to a partial meltdown at the Unit 2 reactor. Water pumps that helped to cool the radioactive fuel in the reactor core malfunctioned.
- Plant staff didn’t realize the reactor was experiencing a loss of coolant and took a series of actions that made the problem worse. These further starved the reactor core of water flow and caused it to overheat.
- The nuclear fuel began to melt through its metal container—about half the reactor core melted. Trace amounts of radioactive gasses escaped into the surrounding community as a geyser of steam erupted from the top of the plant.
- The melting fuel created a large hydrogen bubble inside the unit that officials worried might cause an explosion, releasing even larger amounts of radioactive material.
- Pennsylvania governor Dick Thornburgh advised pregnant women and pre-school-age children within a five-mile radius of the plant to evacuate the area. The crisis ended three days later when experts determined the hydrogen bubble could not burn or explode.

CHERNOBYL REACTOR INCIDENT

- On April 25, 1986, Russian engineers and scientists begin preliminary tests of safety on Chernobyl power plant's 4th reactor. In order to control the experiment, the automatic control system was shut down. After some work, stability was reached at very low power outputs. Unfortunately, manual control of the water pressure wasn't maintained. The reactor began to create excess heat. Without the automatic control, the control rods couldn't be reinserted in time; a deadly chain reaction had begun. Within a matter of 3-4 seconds, the reactor went from 5% output to 100 times its normal level. The water in the reactor flash-boiled, creating an explosion that leveled thousands of tons of concrete and steel, including the housing for the reactor. The steam carried almost 70% of the nuclear material out of the reactor into the surrounding environment. Several thousand
- Volunteers died on the scene, and it is estimated that 7,000 to 10,000 volunteers died in total, considering short and long-term effects. Thousands of miles from the scene, the birth defect rate became double the world average. It is also estimated that 150,000 were put at risk for thyroid cancer, and over 800,000 children were put at risk of contracting leukemia. 2 million acres of land (1/5 of the usable farmland in the Ukraine) was, and still is, completely unusable. It remains difficult to determine the scope of the disaster; radiation resulting from the event was detected all over the globe. It is estimated that it may cost up to $400 billion and will take up to 200 years to correct the damage done to the area, and to compensate those affected by the meltdown.

Date	26 April 1986
Time	01:23 (Moscow Time UTC+3)
Location	Pripyat, Ukrainian SSR, Soviet Union

FUKUSHIMA, JAPAN

- March 11, 2011 Fukushima Daiichi nuclear power plant in Japan confirmed a nuclear accident with resulting in an explosion and radiation leak in the waked of the 9.0 earthquake and major Tsunami that swept 6 miles inland.

- Japan declared states of emergency for five nuclear reactors at two power plants after the units lost cooling ability.

- The nuclear safety agency reported an emergency at second reactor and have evacuated as many as 170,000 people from the areas around two nuclear power plants and the prime minister has warned residents living within 19 miles to stay inside or risk getting radiation sickness.

- After the recent blast radiation detectors showed 11,900 microsieverts of radiation three hours after the blast, up from just 73 microsieverts beforehand. However, health risks are at levels exceeding 100,000 microsieverts.

Radiation Exposure

The potential danger from a nuclear accident is exposure to radiation.

Exposure could result from the release of radioactive material from a nuclear plant into the environment, usually characterized by a plume (cloud-like formation) of radioactive gases and particles.

If a complete reactor meltdown, where the uranium core melts through the outer containment shell, were to occur, a wave of radiation would be released, resulting in major, widespread health problems.

The major hazards to people in the vicinity of the plume are radiation exposure to the body from the cloud and particles deposited on the ground, inhalation of radioactive materials, and ingestion of radioactive materials.

Radioactive materials are composed of atoms that are unstable. An unstable atom gives off its excess energy until it becomes stable.

• Radioactive Fallout from Nuclear Accident or Blast

- Even if individuals are not close enough to the nuclear blast to be affected by the direct impacts, they may be affected by radioactive fallout.
- Any nuclear blast results in some fallout.
- Blasts that occur near the earth's surface create much greater amounts of fallout than blasts that occur at higher altitudes. This is because the tremendous heat produced from a nuclear blast causes an up-draft of air that forms the familiar mushroom cloud.
- Fallout from a nuclear explosion may be carried by wind currents for hundreds of miles if the right conditions exist. Effects from even a small portable device exploded at ground level can be potentially deadly.
- Nuclear radiation cannot be seen, smelled, or otherwise detected by normal senses.
- Radiation can only be detected by radiation monitoring devices. This makes radiological emergencies different from other types of emergencies, such as floods or hurricanes.
- Monitoring can project the fallout arrival times, which will be announced through official warning channels. However, any increase in surface build-up of gritty dust and dirt should be a warning for taking protective measures.
- Electromagnetic Pulse (EMP)
- In addition to other effects, a nuclear weapon detonated in or above the earth's atmosphere can create an electromagnetic pulse (EMP), a high-density electrical field. An EMP acts like a stroke of lightning but is stronger, faster, and shorter.
- An EMP can seriously damage electronic devices connected to power sources or antennas. This includes communication systems, computers, electrical appliances, and automobile or aircraft ignition systems.

Radiation Spares Nothing

- Impacts Vegetation - Agriculture
  - Trees near Jaduguda Uranium Mines have DEFORMED SEEDS
  - Agricultural produce is bound to carry *unacceptable amounts of radioactive content*
- Impacts Animals
  - Radioactive Boars on the rise in Germany (thanks to Chernobyl)
- Impacts Human Beings

home

Some FACTS. . ...

TABLE 1 | Nuclear Weapons Inventories, Using the Latest Available Data for the Nine Nuclear Nations

Country	Date of analysis	Number of Nuclear Warheads
United States	2009	2702[a]
Russia	2009	4830[b]
United Kingdom	2005	200
France	2008	300
China	2008	176
Israel	2006	115–190
India	2008	70
Pakistan	2007	60
North Korea	2006	5–15
Total		8458–8543

[a] An estimated 6,700 additional warheads are in reserve or awaiting dismantlement.
[b] An estimated 8,150 additional warheads are in reserve or awaiting dismantlement.

FIGURE 1 | Hiroshima after a 15-kt bomb was dropped on August 6, 1945. The streets were cleaned before this picture was taken. Where have all the buildings gone? They burned in the resulting fire, pumping thick clouds of black smoke into the atmosphere. (Original picture copied by author from US Air Force Photo Library, Bolling Air Force Base, Washington, DC).

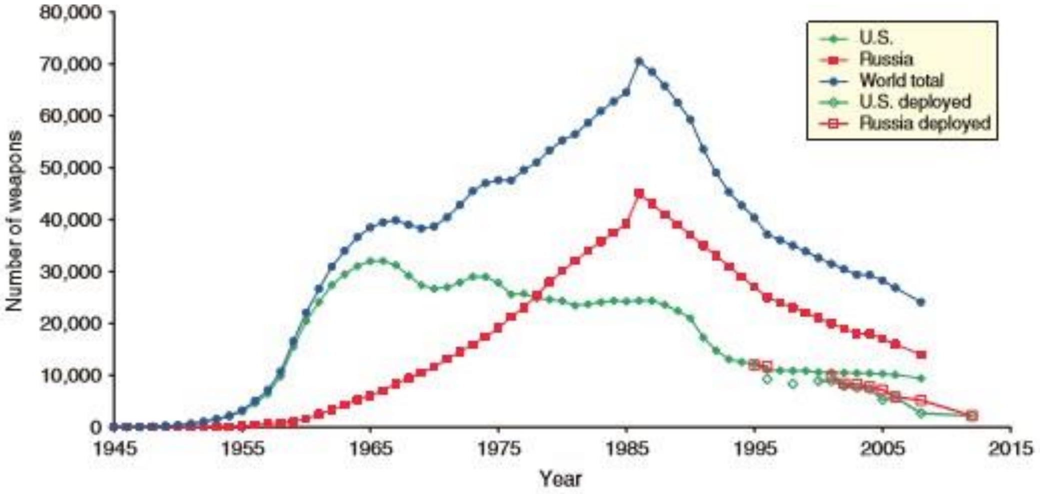


FIGURE 2 | Number of nuclear warheads in Russia (formerly USSR), the US, and the total for all the nuclear weapons states.[16] Russia and the US have more than 95% of the warheads worldwide. The number of warheads began to fall after 1986 following the Intermediate-Range Nuclear Forces Treaty, and by 2005 it was about one-third of its value at the peak in 1986. Current treaties do not require a future reduction in the numbers of warheads, only a reduction in the numbers of warheads that are on strategic delivery systems. Weapons on strategic delivery systems should decline to 1700–2200 for each country by 2012 based on current treaties. (Updated from Figure 1 from Ref 17, used by permission).

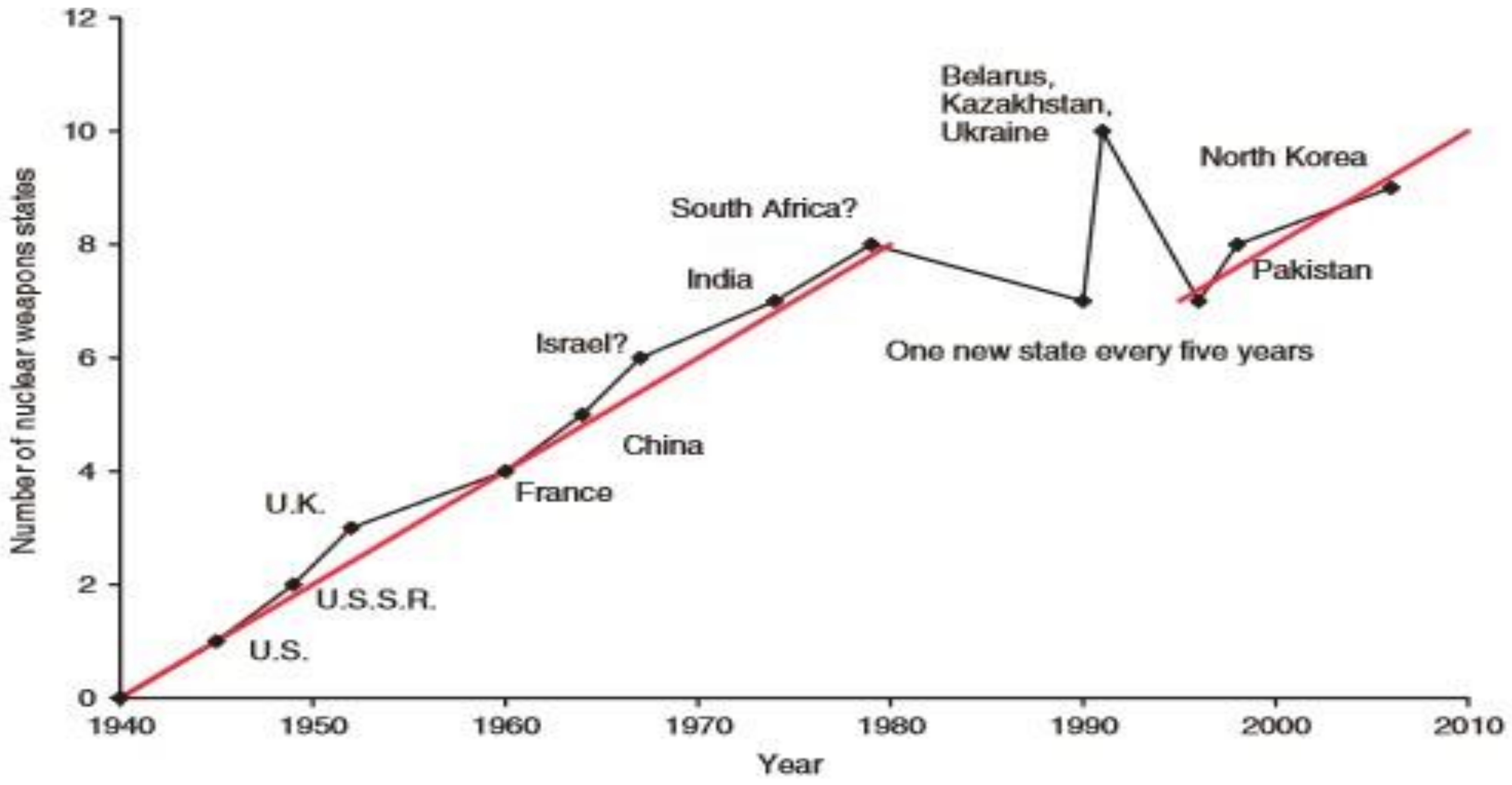


FIGURE 3 | New nuclear states have steadily appeared since the invention of nuclear weapons. In this graph the date of the first test, or the date when weapons were obtained, is noted. Israel and South Africa did not test weapons so their dates to obtain weapons are uncertain. South Africa abandoned its arsenal in the 1990s. Ukraine, Belarus, and Kazakhstan also abandoned the weapons they inherited after they left the Soviet Union. The red lines show growth in the number of nuclear weapons states at the rate of one new state each 5 years. Although the growth halted during the 1980s and 1990s, just after nuclear winter research was published and the Cold War ended, the recent resumption of growth is of great concern.

HOW COULD NUCLEAR WINTER BE PRODUCED?

- Nuclear winter," or as it was initially termed, "nuclear twilight," began to be considered as a scientific concept in the 1980s. **Nuclear winter** is the severe and prolonged global climatic cooling effect hypothesized to occur after widespread firestorms following a nuclear war. The hypothesis is based on the fact that such fires can inject soot into the stratosphere, where it can block some direct sunlight from reaching the surface of the Earth. It is speculated that the resulting cooling would lead to widespread crop failure and famine. In developing computer models of nuclear-winter scenarios, researchers use the conventional bombing of Hamburg, and the Hiroshima firestorm in World War II as example cases where soot might have been injected into the stratosphere, alongside modern observations of natural, large-area wildfire-firestorms
- A nuclear explosion is like bringing a piece of the Sun to Earth's surface for a fraction of a second. About one-third of the energy of a nuclear explosion is in the form of light or heat.
- The assumption made in many nuclear winter scenarios is that anything receiving more than 10 calories per square centimeter per minute (about 7000 W/m2—20 times the average amount of energy received at the top of Earth's atmosphere from the Sun) will burst into flames, and this was demonstrated in actual tests in Nevada before the atmospheric nuclear test ban. Megacities have developed in India and Pakistan and other developing countries, providing tremendous amounts of fuel for potential fires.
- Following the flash of light comes the blast wave (like thunder following lightning) which will break apart many structures and blow out the flames, but crumpled structures burn more easily and fires would be reignited by burning embers and electrical sparks.

- The direct effects of the nuclear weapons, blast, radioactivity, fires, and extensive pollution would kill millions of people, but only those near the targets. However, the fires would have another effect. Massive amounts of dark smoke from the fires would be lofted into the upper troposphere, 10–15 km above Earth's surface in the tropics and 6–8 km above the surface in higher latitudes, and then absorption of sunlight would further heat the smoke, lifting it into the stratosphere, a layer where the smoke would persist for years, with no rain to wash it out.